UNIVERSITY OF THE ALGARVE

FACULTY OF ECONOMICS

THE IMPACT OF BUSINESS AND CLINICAL INTELLIGENCE PROJECT *HVITAL*: A CASE STUDY IN THE *SÃO JOÃO* HOSPITAL CENTRE, *EPE*

SARA FILIPA SALVADOR DA LUZ

Dissertation to obtain a Master's Degree in Healthcare Management

Supervised by:

Professor Dr. Luís Coelho

Professor Dr. Adão Flores

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Authorship and Copyright Declaration

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Work Authorship Declaration

I declare to be the author of this work, which is unique and unprecedented. Authors and works consulted are properly cited in the text and are in the listing of references included.

Sara Filipa Salvador da Luz

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If you can't measure it, you can't manage it

Peter Drucker

ABSTRACT

In recent years, healthcare organisations have been under increased pressure to produce more with less, seeking ways to ensure that resources are employed as efficiently as possible while ensuring quality of care. Good information is the key to accomplish these goals. No organisation can be effectively managed without the proper information in a timely manner. Getting the right information to the right people at the right time is the central to control an organisation and improve decision making. However, transform massive volumes of data into information is not an easy task, especially when data are stored in incompatible formats and are dispersed by different information systems that do not communicate with each other. To tackle this issue, investments on Business Intelligence systems are being made to support the management role in the healthcare sector, which, in turn allow a quick and deeper understanding of all management and clinical processes. Thus, this dissertation presents an exploratory case study aiming to evaluate the impact of implementing a Business and Clinical Intelligence project in 2012, called *HVITAL*, in the *São João* Hospital Centre, *EPE*, Oporto. The methodology used in the case is a mixed method research in which quantitative and qualitative data are analysed between 2010 and 2014. In particular, both financial statement and contract programme analyses are performed using data collected from annual reports and other secondary sources provided by the hospital. Further, this study uses thematic analysis with data gathered from 12 face-to-face semi-structured interviews with key-participants. The main findings suggest that, from a quantitative perspective, it is hard to identify a clean link between the implementation of the *HVITAL's* project and the performance of the *São João* Hospital Centre, *EPE*. Yet, the qualitative analysis clearly suggests that the *HVITAL* has had a positive and significant impact on the managements´ and clinical performance levels.

Keywords: management control; performance measurement; business intelligence; clinical intelligence; healthcare; hospital.

RESUMO

A atual situação socioeconómica e financeira do país tem aumentado a exigência das organizações de saúde em produzirem mais com menos, com vista a garantirem uma maior eficiência na utilização dos recursos disponíveis e a assegurarem, em simultâneo, a qualidade dos cuidados prestados. A chave para se atingirem tais objetivos passa pela produção de boa informação em saúde. Nenhuma organização pode ser gerida de forma eficaz sem informação adequada e em tempo útil. Obter a informação certa, para as pessoas certas, no momento certo é essencial para controlar uma organização e melhorar o processo de tomada de decisão. Contudo, transformar volumes massivos de dados em informação não é uma tarefa fácil, especialmente quando os dados são armazenados em formatos incompatíveis e estão desagregados e dispersos por diferentes sistemas de informação que não comunicam entre si. Para colmatar a falta de interoperabilidade entre os sistemas de informação existentes nas organizações de saúde, e consequente falta de medição da *performance* de forma fidedigna e em tempo oportuno, têm sido realizados investimentos em sistemas de *Business Intelligence.* Estes sistemas incorporam ferramentas tecnológicas capazes de transformar os dados exportados de bases de dados (i.e., dados provenientes de diferentes sistemas de informação) em informação útil, apoiando os gestores na obtenção de uma compreensão rápida e profunda sobre os processos organizacionais. Este conhecimento traduz-se, portanto, numa melhor tomada de decisão. Nos últimos anos, os sistemas de *Business Intelligence* têm sido amplamente utilizados em vários setores de atividade. No setor da saúde é algo recente. De acordo com a revisão de literatura efetuada, algumas organizações de saúde nacionais e internacionais já começaram a investir na implementação destas plataformas tecnológicas. No entanto, e apesar de existirem diversos artigos de opinião e revisões de literatura internacionais sobre o assunto, os estudos empíricos são escassos. Deste modo, a presente dissertação apresenta um estudo de caso exploratório, com o objetivo de avaliar o impacto da implementação de um projeto de *Business* e *Clinical Intelligence* em 2012, chamado HVITAL, no Centro Hospitalar de São João, EPE, Porto, no período compreendido entre 2010 e 2014. Selecionou-se o Centro Hospitalar de São João, EPE enquanto amostra do estudo por ter implementado um sistema de *Business* e *Clinical Intelligence* com uma maturidade de dois anos, o que por si só permitiu uma análise comparativa de pré (2010 e 2011) e pós implementação do sistema (2013 e 2014). Outras razões que mereceram atenção na escolha da amostra relacionaram-se com o facto do Centro Hospitalar de São João, EPE ter sido distinguido nacional e internacionalmente

pelo investimento e inovação realizados com a implementação do HVITAL, pela sua *performance* económica e financeira positiva entre os anos de 2010 e 2014 e por ter sido considerado o melhor hospital do país em 2013 e 2014 pela Escola Nacional de Saúde Pública. Para responder às questões de investigação colocadas, adotou-se uma metodologia de investigação mista. Em termos de abordagem quantitativa, o estudo teve como principal objetivo responder ao impacto do projeto HVITAL aos níveis de *performance* de gestão e clínica. Para tal, procedeu-se a uma análise económica e financeira dos balanços e das demonstrações de resultados do hospital, para o período de estudo em análise (2010-2014). De seguida, foram analisados os resultados dos objetivos de qualidade e eficiência dos contratos-programa contratualizados entre o hospital e a Administração Regional de Saúde do Norte para o período análogo. Os dados utilizados para a abordagem quantitativa foram recolhidos a partir dos relatórios e contas disponibilizados no *website* do Centro Hospitalar de São João, EPE e de outros documentos secundários fornecidos pela equipa de gestão do hospital. No que respeita à abordagem qualitativa do estudo, os dados foram recolhidos através de 12 entrevistas semi-estruturadas, realizadas a participantes-chave da organização, nomeadamente, gestores, profissionais de saúde e o gestor do projeto HVITAL, entre 16 e 17 de dezembro de 2015. Estes dados foram, posteriormente, analisados com recurso a uma análise temática, denominada *Framework approach*, com vista a complementar as questões do estudo quantitativo, apurar as razões que levaram o hospital a implementar um projeto de *Business* e *Clinical Intelligence* e os aspetos mais relevantes sobre a operacionalização do projeto. Do ponto de vista quantitativo, os resultados sugerem que é difícil estabelecer uma relação direta entre a implementação do projeto HVITAL e a *performance* do Centro Hospitalar de São João, EPE. Considerou-se que as diversas medidas estruturais implementadas nos últimos anos no Sistema de Saúde Português, a maioria em resposta à crise económica e financeira e à reforma hospitalar, assim como a dificuldade subjacente à medição de *outcomes* nas organizações de saúde, possam ter tido uma forte influência na análise efetuada. No entanto, a análise qualitativa levada a cabo sugere claramente que a implementação do projeto HVITAL teve um impacto positivo e significativo nos níveis de *performance* de gestão e clínica do hospital, destacando-se a sua influência na produção de informação precisa, fidedigna, oportuna, e acessível a todos os profissionais da organização. Após ter sido implementado com o intuito de melhorar o controlo de gestão, o HVITAL contribuiu para que os gestores alcançassem melhores níveis de controlo e conseguissem tomar decisões mais rápidas, com base nos números.

Os gestores ganharam a capacidade de saber onde é utilizado o dinheiro, monitorizar regularmente os indicadores de produção e os de qualidade e melhorá-los através da adoção de medidas corretivas em tempo útil, promover a *accountability*, ajustar os recursos às necessidades identificadas (e.g. encerrar salas de bloco operatório, diminuir o número de camas, anticipar a rutura de stocks), e realizar análises mais detalhadas. Da mesma forma, os profissionais de saúde passaram a conseguir visualizar as tendências dos parâmetros dos pacientes regularmente, podendo prioritizar as necessidades dos mesmos com base no nível de risco de deterioração, identificar más práticas de forma mais rápida, analisar diferentes indicatores clínicos em simultâneo, e envolver-se com maior frequência em projetos que caso não estivessem integrados com o HVITAL não seriam passíveis de ser realizados. Por último, os resultados sugerem que a combinação do projeto HVITAL com uma boa estrutura de gestão e profissionais motivados é a chave para melhorar o processo de tomada de decisão. Com a presente dissertação espera-se contribuir para o desenvolvimento científico desta temática tão recente no setor da saúde em Portugal, abrindo caminho para a produção científica nacional sobre esta área de interesse e, particularmente, sobre o projeto HVITAL. São ainda pretensões claras desta dissertação dar visibilidade ao trabalho desenvolvido pelo Centro Hospitalar de São João, EPE e preconizar a importância do processo de tomada de decisão eficaz.

Palavras-chave: controlo de gestão; medição da *performance*; *business intelligence*; *clinical intelligence*; saúde; hospital.

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LIST OF ABBREVIATIONS

ACSS	Central Administration of the Health System
AP	Economic and Financial Adjustment Programme
BI	Business Intelligence
BCI	Business and Clinical Intelligence
CP	Contract program
CR	Current ratio
DOH	Days of inventory on hand
DRG	Diagnosis-related group
DSO	Days of sales outstanding
DSS	Decision support system
EBIT	Earnings before interest and taxes
EBITDA	Earnings before interest, taxes, depreciation and amortization
EPE	Public Enterprise
ESS	Executive support system
IS	Information system
KPI	Key performance indicator
MIS	Management information system
MOH	Ministry of Health
NHS	National Health Service
OECD	Organisation for Economic Co-operation and Development
PHS	Portuguese Health System
PPP	Public and private partnerships
RHA	Regional Health Authority
ROA	Return on assets
ROE	Return on equity
SJHC	*São João* Hospital Centre, EPE
TPS	Transaction processing system
USA	United States of America

Chapter 1. INTRODUCTION

1.1 Problem formulation and purpose

In today's organisational fast changing, managing complex organisations requires good control, whether organisations are profit or non-profit oriented (Anthony, Dearden and Bedford, 1984). To successfully control an organisation, managers must establish performance standards, compare them against strategic objectives and take action to correct deviations from the standards, performing all steps based on accurate, reliable and timely information (Higgins, 1994; Wheelen and Hunger, 1995).

Information systems (ISs) play an important role providing feedback on organisational activities, and helping to support managerial decision-making process (Daft, 1994; Higgins, 1994; Bocij, Chaffey and Hickie, 1999). Yet, obtaining good information from ISs can be challenging, especially when data is stored in incompatible formats and are disaggregated and dispersed by different systems that do not communicate with each other. In the Portuguese Health System (PHS), this became particularly evident after the global economic and financial crisis, since poor information was pointed out as one of the most difficulties to decision makers manage change (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

While other sectors have been facing the growing demand of good information by implementing Business Intelligence (BI) systems, many healthcare organisations have only started recently. This can explain the reduced number of empirical studies about BI systems implemented in healthcare organisations, in opposition to other industries. Apart from this, several literature reviews and opinion articles about BI systems in healthcare organisations were found, however, to address the empirical research gap, the aim of this study is to evaluate the impact of implementing a Business and Clinical Intelligence (BCI) project in 2012, called *HVITAL*, in the *São João* Hospital Centre, EPE (SJHC), Oporto, between the period of 2010 to 2014.

This dissertation presents an exploratory case study (Saunders, Lewis and Thornhill, 2009; Yin, 2009), which looks at the impact of the *HVITAL*'s project on the performance of the SJHC, both at the managerial and clinical levels. This study also addresses why the *HVITAL* was implemented in the first place, and details how it was put into practice.

The present study employs a mixed research method to look at the different aspects of interest (Saunders, Lewis and Thornhill, 2009; Yin, 2009; Bryman, 2012;

Pickard, 2013; Creswell, 2014). In terms of quantitative approach, a financial statement analysis of balance sheets and income statements was performed for the period 2010 to 2014. In particular, common-size financial statement analysis and ratio analysis are used to obtain information about the economic and financial health of the SJHC (Higgins, 1994; Subramanyam and Wild, 2009). Furthermore, the results of the quality's and efficiency objectives of the contract programmes (CPs) signed between the hospital and the North Regional Health Administration in the period from 2010 to 2014 are also analysed. In terms of qualitative approach, a study was put in practice to capture, portray and explain interviewees' perceptions about the phenomenon of interest (Yin, 209), building a more interpretive analysis through a thematic analysis, called Framework approach (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014; Spencer, Ritchie, O'Connor, Morrel and Ormston, 2014). The qualitative data was obtained from 12 semi-structured interviews of key stakeholders (i.e., managers, healthcare professionals and the *HVITAL's* project manager), between 16 and 17 December 2015.

1.2 Research questions

On the basis of the research objective of this study, i.e. evaluating the impact of the BCI project *HVITAL* in the SJHC for the period 2010 to 2014, a set of research questions were formulated as follows:

Q1. How did the *HVITAL's* project affect the managerial performance?

Q2. How did the *HVITAL's* project affect the clinical performance?

Q3. Why was the *HVITAL's* project implemented?

Q4. How was the *HVITAL's* project implemented?

By answering the two first questions, this study aims at evaluating the impact of the *HVITAL's* project on the SJHC managerial and clinical performance (quantitative perspective). For completeness purposes (Bryman, 2012), and to understand why the *HVITAL's* project was implemented in the first place, and details how it was put into practice, this research has the objective to explore the participants' perceptions (qualitative perspective).

1.3 Main results

The main quantitative findings suggest that it is hard to establish a direct link between the implementation of the *HVITAL's* project and the performance of the SJHC.

This could be explained by the structural changes in the PHS, mostly in response to the global financial and economic crisis and to the hospital reforms that have been undertaken in the last decades, or even by the difficulty to measure outcomes in healthcare organisations. Nevertheless, financially speaking, it is clear that the SJHC outperforms other publicly owned hospitals in the period under scrutiny. Furthermore, there is some evidence to suggest that the operating performance of the SJHC improved both in quality and efficiency after 2012.

More importantly, the qualitative study employed finds that the *HVITAL's* project has had a positive and significant impact on the managements' and clinical performance levels, especially for producing accurate, reliable, timely and accessible information to all professionals. After being initially implemented to solve management control issues, the *HVITAL* helped managers to achieve better control and take decisions more quickly than before, with basis on numbers. Managers gained the real-time capacity to know where the money is used, monitor closely indicators and improve it by taking corrective action in a timely manner, promote professional accountability, adjust resources to the needs (e.g. close operating rooms, decrease the number of beds, anticipate stock ruptures), and perform more comprehensive analyses. In the same vein, healthcare professionals gained the ability to check the tendencies of patients' parameters regularly prioritising their needs with basis on the deterioration risk levels, quickly identify bad practices, perform analyses with different clinical indicators at the same time, and get more involved in projects that would be impossible to work without the integration of the *HVITAL*. Such results are in line with the previous empirical studies approached in this research (Gonçalves, Santos and Cruz, 2010; Horvath, Winfield, Evans, Slopek, Shang and Ferranti, 2011; Agnoletti, Buccioli, Padovani, Corso, Perger, Piraccini, Orelli, Maitan, Dell'Amore, Garcea, Vicini, Montella and Gambale, 2013; Foshay and Kuziemsky, 2013; AlHazme, Rana and De Lucca, 2014; Chamney, Mata, Viner, Archibald and Peyton, 2014), where is highlighted, in general, the positive impact of BI systems in healthcare organisations. Finally, the findings suggest that combining the *HVITAL's* project with a good management structure and motivated professionals is the key to improve decision-making process.

1.4 Value of the research

Having researched empirical studies into BI systems in healthcare organisations recently, a surprisingly small number of international and national articles were found,

making possible to this dissertation add the experience of implementing a BI project in a Portuguese healthcare organisation to the empirical literature. The main results of empirical studies found will be further discussed later in detail. Apart from this, this study also presents some considerations of literature reviews and opinion articles aiming at get an overview of the impact of BI systems in healthcare organisations worldwide.

The second reason of this research's value lies of getting the perceptions of a variety of individuals about the BI system in study, combining it with a quantitative perspective. This could be valuable for scientific research, since mixed methods research are exceptionally rare in this particular subject.

A third value lies in spreading the importance of this topic in healthcare community. Likewise the SJHC, other hospitals can place themselves ahead of the game in their approach to BI. By developing similar ways of using real-time data capabilities, they can overcome the barriers of having data stored in incompatible formats, dispersed and disaggregated by different ISs, enhance performance measurement, and improve managerial and clinical outcomes.

1.5 Structure of the dissertation

This dissertation is organised as follows. Chapter 2 presents the theoretical background, where issues of management control and performance measurement through ISs are briefly addressed. A particular emphasis is also given to the state of art about BI systems in healthcare organisations. Chapter 3 presents the case study, beginning with a brief overview of the PHS, describing how it is organised and some of the latest reforms to improve National Health Service's performance. Further, a historical background of the SJHC is included, as well as the implementation context of the *HVITAL*'s project. The research methodology is then introduced, comprising the participants, the nature of the data collection methods and data analysis instruments. This chapter ends with the analysis of the quantitative and qualitative research findings. In chapter 4 the main findings are discussed. Chapter 5 concludes. This last chapter ends summarising the contributions and limitations of the dissertation, and suggesting future research avenues.

Chapter 2. THEORETICAL BACKGROUND

2.1 Planning and control in healthcare management

Control is concerned with whether objectives have been achieved and strategic plans carried out efficiently and effectively (Higgins, 1994). For Anthony, Dearden and Bedford (1984, p. 4), control "is a broad concept applicable to people, things, situations, and organizations. In organizations, it includes both management control and other planning and controlling processes". As such, planning and control are two interdependent concepts. On the one side, planning depends on the results of the control process, involving the elaboration of strategic plans. On the other, controlling is concerned with whether objectives have been achieved and strategic plans carried out efficiently and effectively (Higgins, 1994).

The control process ensures that organisational strategies are successful in attaining what is set out to accomplish, by comparing performance with the desired results and providing the feedback required for managers evaluate results and take corrective action as necessary (Wheelen and Hunger, 1995). The results associated with accomplishing objectives in business sector are most frequently expressed in financial terms and reported in the two most important financial reports of an organisation, the balance sheet and the income statement (Higgins, 1994).

According to Anthony, Dearden and Bedford (1984) "an organisation's effectiveness is measured by the extent to which its outputs accomplish its objectives, and its efficiency is measured by the relationship between inputs and outputs". This perspective, however, does not cope with the fact that measuring results in a non-profit organisation is more challenging than in a profit-oriented one (Anthony, Dearden and Bedford, 1984).

One of the dominant purposes of some organisations is earning profits. Managers make their decisions based on profits increase and performance is mainly measured in terms of profitability. On the other hand, other organisations, such as public hospitals, aim to contribute to the public welfare. This type of organisations exist to render a service and managers concerns are related with efficiency and quality of the service rendered (Anthony, Dearden and Bedford, 1984).

There are other reasons to distinct non-profit organisations from the profit-oriented one. 'Service' is more vague than 'product", which makes performance measurement more demanding. The relationship between costs and benefits is difficult to

measure, especially at the benefits level. Some non-profit organisations obtain their financial resources from sales revenue (e.g. most general hospitals in USA), other receive a significant amount of financial support from other sources (e.g. public supported organisations, such as charitable organisations and foundations). In a healthcare organisation there is no relationship between the number of the clients and its success, and additional clients may place a strain on resources instead of increase profit. There are also differences in governance, senior management, number of professionals and a tradition of inadequate management (Anthony, Dearden and Bedford, 1984).

Although the values and practices of profit-oriented organisations differ from non-profit ones, an organisation must be controlled and managers are responsible to assure that resources are used in an efficient and effective manner (Anthony, Dearden and Bedford, 1984; Swayne, Duncan and Ginter, 2008). As a result, many of the management control methods initially developed in the business sector have been adopted by healthcare organisations in the last decades (Swayne, Duncan and Ginter, 2008). Nonetheless, the absence of satisfactory measures of performance is the most serious problem of management control in a healthcare organisation. The central problem is the lack of good measures of outputs, since inputs can be measured readily in both types of organisations (Anthony, Dearden and Bedford, 1984; Swayne, Duncan and Ginter, 2008).

2.2 Information systems for performance measurement

Performance measurement is vital for good management control. If managers are going to have good control, they need to know how the production system works, the way is currently performing and what normal performance looks like and, finally, compare all against organisational strategic objectives (Kaydos, 1991). However, the lack of quantifiable objectives or performance standards, and the inability of having adequate information are two obvious control problems (Wheelen and Hunger, 1995).

ISs may provide timely performance measurements and useful information to effective decision making, instead of managers taking decisions with basis on subjective judgement (Daft, 1994; Higgins, 1994; Bocij, Chaffey and Hickie, 1999). These systems can change the flow of information, making possible for all users' access the same information and share it, which accelerates the decision-making process (Laudon and Laudon, 2014).

There are different kinds of ISs to support the decision-making needs of each management level. These systems comprise transaction processing systems (TPS) and systems for BI (Laudon and Laudon, 2014).

A TPS is a computer-based system that keeps track daily activities and transactions of the organisation, such as sales, receipts, cash deposits, payroll, credit decisions, and inventory, among others. The main purposes of this IS is to answer easily to the routine questions for operational managers conduct business processes, and produces information for other systems and business functions (Laudon and Laudon, 2014).

BI systems combine the capabilities of management information systems (MISs), decision support systems (DSSs) and executive support systems (ESSs), which previously operated as independent systems. Nowadays, one set of hardware and software tools in the form of BI and analytics package can integrate all information provided by the three systems and making it easily accessible to managers' desktop. MISs, DSSs and ESSs deal with distinct complexity issues addressed to different levels of management (Laudon and Laudon, 2014).

MISs designate a type of IS used to monitor and control administrative activities. These systems focus on tactical issues, supporting middle management with regular scheduled reports about the organisation's current performance. MISs typically provide answers to routine questions that have been identified in advance, using data supplied by TPSs. Most MISs are not flexible and have few analytical capabilities, using summaries and comparisons as opposed to sophisticated mathematical models or statistical methods (Bocij, Chaffey and Hickie, 1999; Laudon and Laudon, 2014).

DSSs support middle management with more non-routine decision making. These systems focus on tactical and strategic issues, both in respect to the internal and external environments. They are typically used to solve business problems that are unique and rapidly changing, which makes no possible to have predefined procedures in advance to find solutions. Although DSSs use internal data supplied by TPSs and MISs, they often use data from external sources. DSSs serve the decision-making needs of "super-user" managers and business analysts requiring sophisticated analytics and models to analyse data (Bocij, Chaffey and Hickie, 1999; Laudon and Laudon, 2014).

ESSs are commonly considered a specialised form of a DSS, serving the decision-making needs of senior management. These systems focus on strategic issues and long-term trends, both in respect to the internal and external environments. ESSs are designed

to address non-routine decisions, filtering, compressing and tracking critical data from internal MISs and DSSs and external, displaying the data of greatest importance to senior managers. Likewise DSSs, there is no predefined procedures in advance to find solutions. ESSs include sophisticated BI tools for analysing trends, forecasting and monitoring data at a greater level of detail. Information is presented in the form of reports and executive dashboards, which displays graphs and charts of key performance indicators (KPIs) on a single screen, through an easy-to-use interface (Bocij, Chaffey and Hickie, 1999; Laudon and Laudon, 2014).

2.3 Business Intelligence in healthcare management

2.3.1 Definition

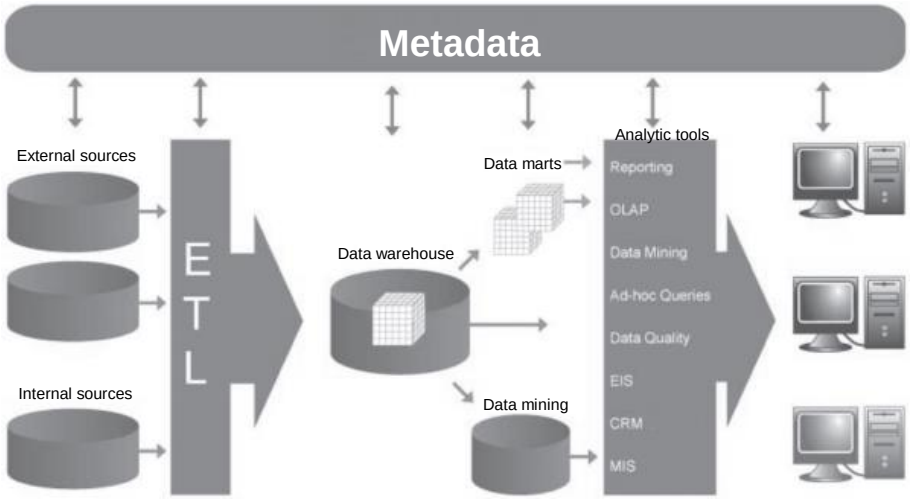
BI is a concept originally created by an IBM researcher Hans Peter Luhn in 1958 (Luhn, 1958), but until the middle 1990s had no much expression being often referred as ESS. Since then, it started to catch widespread attentions. At a certain time ESS began to offer additional visualisation, alerts and performance measurement capabilities, and the Gartner Group (world leading's technology research consultant agency) coined it as BI (Wang, 2013).

BI systems combine architecture, methodologies, components (e.g. extraction, transformation and loading [also known as ETL process], data warehouse, business analytics, data marts, business performance management, and user interface) and tools (e.g. reports and queries, online analytical processing [also known as OLAP], dashboards, scorecards, data mining, text mining) for gathering, integrating, analysing and presenting large volumes of information to achieve a clear understanding of business processes, enable more effective strategic, tactical and operational insights, and accomplish better decision making (Turban, Sharda, Delen and King, 2010).

The components and tools are intended to assist managers with organisation's performance analysis, converting data into useful information, then to decisions and in the end to actions. Figure 2.3.1 presents a typical BI system architecture showing that data is constantly captured and filtered from a wide variety of external and internal sources or databases (e.g. administration, laboratory, medical, and nursing records, and others), then it is extracted, transformed and loaded (i.e. ETL process) into a big centralised repository (i.e. date warehouse), which is composed by subsets of data marts. Finally, and depending on organisational purposes, information gain strategic

significance and it is efficiently communicated to decision makers by standardised reports, which are built with basis on past, present and future trends through data analytic tools (Sezões, Oliveira and Baptista, 2006; Turban, Sharda, Delen and King, 2010; Wang, 2013).

Figure 2.3.1 – A typical Business Intelligence system architecture



Source(s): Sezões, Oliveira and Baptista (2006)

The major benefit of BI systems is its ability to provide accurate and reliable information whenever is needed, including a real-time access to data, providing opportunities for managers to conduct analyses of historical and current data about organisational performance, and make better and more informed decisions through a user-friendly interface (Turban, Sharda, Delen and King, 2010).

2.3.2 Previous studies

The literature reviews and opinion articles about the BI systems in healthcare organisations are consensual in three issues: (1) these intelligence systems are valuable information technologies that enhance financial, operational and clinical (or patient care) performance; (2) the increasing internal and external economic and financial pressures has influenced healthcare organisations to begin making greater use of BI and analytic tools; and (3) the multiple and disparate ISs created among healthcare organisations in the last decades have led to the existence of disaggregated and dispersed data, which contributed to confuse more than help. In these articles, several cases of successful

performance improvement are reported, in large part attributable to effective implementation of BI systems, as described following.

Maine Medical Centre in Portland, Maine, United States of America (USA), after implementing a BI system verified that only 70 percent of congestive heart failure patients were receiving all treatment recommended by the Joint Commission's standards, and decided to take corrective action putting themselves now at 95 percent of performance. This improved quality of care and revenue, since meeting a high percentage of guidelines is critical to receive higher reimbursements (Burke and Ingraham, 2008).

By closely monitoring the cost, productivity, quality and patient experience in real-time, the Cleveland Clinic, Ohio, USA, was able to reduce costs, particularly in nursing overtime by labour agencies, raw utilisations of blood products, and ineffectively clinicians' organisation in seasonal periods (Wadsworth, Graves, Glass, Harrison, Donovan and Proctor, 2009).

The Duke University Care Nursery, North Carolina, USA, after implementing a BI system and successfully reduce costs, it is now using the system to achieve better quality and patient safety outcomes (Ferranti, Langman, Tanaka, Mccall, Ahmad, 2010).

New West Physicians is a primary care group (80 providers in 16 locations) serving the Denver area, Colorado, USA, with a BI system that identifies if physicians are following the guidelines of treatment. When a physician does not follow it is automatically notified to carry out the corrective action or justify the reasons for the chosen treatment. Further, every time a New West physicians' patient is admitted in one of their hospitals, the primary care physician is immediately alerted to caring for and closely monitoring the patient during the hospitalisation time (Coddington, 2012).

The Methodist healthcare, composed by eight-hospital, in San Antonia, Texas, USA, is no longer waiting for end-of-the-week, end-of-month, or end-of-quarter reports to manage change. Since a BI system was implemented, this organisation has improved a number of indicators, such as the bed assignment (reduced by 78 percent), and the annual budget (increased by 8 percent) (Baim, 2012).

Some of the authors also claimed predicting future trends as one of the most powerful advantages of the BI systems, such as associations between medications, laboratory results and problems (Wright, Chen and Maloney, 2010), attacks of chronic diseases by considering of both bio-signals of patients and environmental factors (Lee, Chen and Tseng, 2011), nursing diagnoses, outcomes and interventions for constructing nursing care plans (Duan, Steet and Xu, 2011; Almasalha, Xu, Keenan, Khokhar, Yao,

Chen, Johnson, Ansari and Wilkie, 2012), stratification of patients' risk levels (Glaser, 2014), surgical outcomes and the prognostic factors of complex medical procedures as a coronary artery bypass grafting (Delen, Oztekin and Tomak, 2012; Shen, Jigjidsuren, Dorjgochoo, Chen, Chen, Hsu, Wu, Hsueh, Lai, Tan, Altangerel and Lai, 2012; Teow, El-Darzi, Foo, Jin and Sim, 2012), and identification of missing charges, detection of underpayments and automatized resolution of credit balances (Bradley and Kaplan, 2010).

Although all potential benefits identified by the previous articles, there are scarce empirical researches on this area, having found only six reliable studies to be discussed in detail, as following.

Believing on the potential value that BI systems can provide for healthcare organisations, Foshay and Kuziemsky (2013) employed a case in the Guysborough, Antigonish, Strait-Area Health Authority in Nova Scotia, Canada, presenting the most critical factors that should be addressed in the early stages of a BI system implementation (i.e. what a healthcare organisation needs to consider prior to implementing a BI system), and the adverse impacts do decision-making process and its root causes. According to their findings, in the absence of timely access to the right information, the decision-making process takes longer than required given the length of time to obtain information. In such case, managers give up on getting the facts and data needed to make decisions, deciding solely based on experience and intuition. Foshay and Kuziemsky (2013) claim that addressing this issue by implementing effective BI systems could be significant advantageous for healthcare organisations. After reach these conclusions, the authors identified a number of root causes to sub-optimal decision-making process, dividing them into three distinct categories: informational, process and personnel issues.

Regarding informational issues, poor information quality, and ineffective access and dissemination of information emerged as the main barriers to effective decision making, more particularly: (i) data were not of sufficient quality or available in a timely manner, with a lag of several months; (ii) data were not stored electronically, requiring a good effort to manual input and assembly; (iii) reports manually exported into Excel® were recognised as labour intensive and time-consuming; (iv) information was not be formatted in an easy-to-use interface to staff outside of the finance and procurement fields; (v) information was inconsistent disseminated among professionals; and (vi) professionals have learned that information needed was excessively difficult to obtain, which contributed for they given up on acquiring it. In terms of process issues, both

information production and consumption seemed to interfere with the decision-making process. From a production perspective, all information requests were ad hoc in nature, which contributed to not receive the information in a timely manner. From the consumption point of view, there were no standards in place in terms of how the core processes within the health district should empirically measure, as well as a lack of understanding of what information is needed to accomplish this purpose. Additionally, the lack of definition of the information needed to monitor and measure core processes made it hardly possible to assess organisational efficiency and effectiveness. In terms of personnel issues, the lack of relevant individual skills and knowledge to perform data analysis and give an appropriate use of information it was also seen as an obstacle to effective decision making. Moreover, even in the case of the district have access to an effective BI system, this issue would remain troublesome since professionals would not be able to exploit data (Foshay and Kuziemsky, 2013).

Horvath, Winfield, Evans, Slopek, Shang, and Ferranti (2011) reported the development of a research portal by the Duke University Health System (comprises two community hospitals and an academic facility) in August 2008, called Duke Enterprise Data Unified Content Explorer, aiming to access clinical data stored in the data warehouse already implemented at the Duke University Health System, Durham, North Carolina, USA. To accomplish that, the authors decided to implement a first tool in the research portal using BI tools, called Guided Query. The main findings suggested that the system developed could enable researchers to collect data autonomously and in a harmonised manner. Yet, the researcher's autonomy may be risky since they can misunderstand basic properties of archived clinical data and use it inappropriately.

To address the gap between the quantity and type of clinical problems that Residents face during their training and those required by program guidelines, Chamney, Mata, Viner, Archibald and Peyton (2014) evaluated the development of a Practice Profile Application, called Resident Practice Profile, using a BI application framework. This application was developed in collaboration with a team of researchers and Family Medicine physicians at the University of Ottawa, Canada, aiming to collect data directly into a reporting database to monitor clinical indicators, such as types of patients, diagnoses and procedures performed, and consequently provide ability for Residents assess their clinical experience (or performance). For developing the Resident Practice Profile, the team started by analysing the existing technologies, and then decided to use three different BI application frameworks (NetBeans 8.0, QuickForms 1.0 and

QuickForms 3.0) by comparing them in terms of effectiveness. At the end of this process, the team found that the BI application framework (in this case the QuickForms 3.0), has greatly improved their ability to configure the Resident Profile Application and reduced the development effort.

Agnoletti, Buccioli, Padovani, Corso, Perger, Piraccini, Orelli, Maitan, Dell'Amore, Garcea, Vicini, Montella and Gambale (2013) studied the impact of a BI system implementation in an operating room of an Italian public hospital, in 2009, called Surgical Patient Path. The aim was to increase surgical theatres efficiency, patient safety measures and a fair distribution of hospital resources among healthcare professionals, with basis on cost reduction, but maintaining the same quality and productivity levels. The authors found a direct link between the BI implementation and the results obtained between January 2009 and December 2011, which are presented as follows: (i) the operating room performed 14675 surgeries and data were gathered from 14337 patients; (ii) the number of surgical procedures were 4892 in 2009, 5616 in 2010 and 5120 in 2011; (iii) raw utilisation were 44% in 2009, 56% in 2010 and 52% in 2011, with the same operating room block time and hours of allocated block time; (iv) the number of unscheduled procedures performed and overtime has reduced while maintaining the same percentage of surgical procedures; (v) the number of high complexity surgical procedures (above 120 minutes) has increased in 2011 when compared to 2009 and 2010, for General Surgery, Eyes, Nose and Throat, Urology and Orthopaedic-Traumatology Surgical Units; (vi) Thoracic and Vascular Surgical Units have decreased its procedures from 48 to 45%; and (vii) no adverse events occurred in the available years when compared to the previous two years (2007-2008). Overall, the authors concluded that the BI system enables a real-time analysis of each patient's surgical path every step of the way, as well as a clearer picture of the complex operating room System on a macro level. Also, it has improved the efficiency of the operating room process and patient safety, and represent a successful experiment of the introduction of managerial innovation in a public hospital, aligning managerial and healthcare professional objectives.

AlHazme, Rana and De Lucca (2014) described the impact of a BCI system implementation in a non-profit organisation, in Florida, USA. The main goal was to bridge the gap between the data available and already accessed by decision makers, through a data warehouse previously implemented, and the data needed to plan and coordinate Florida healthcare services adequately. According to the authors, the BCI system was successfully implemented and yielded a number of positive outcomes, as

follows: (i) shortness of the time needed to analyse data (which typically required months to compile) and to decision-making process; (ii) up-to-date and synthetized information to develop county health plans (which typically consisted of hundreds of pages); and (iii) ability to end-users set-up the desirable data to analyse and create reports whenever they want, through a user-friendly interface (which typically needed a significant number of professionals). AlHazme, Rana and De Lucca (2014) concluded that these immediate outcomes enabled to reduce costs and time consumption in planning and coordinating healthcare services. Further, there are also a number of anticipated advantages given the capabilities of the system, such as improving the coordination and distribution of health resources across the State and enhancing the quality of care, through real-time reporting and data mining capabilities.

Gonçalves, Santos and Cruz (2010) reported the design and implementation of a BI system to evaluate the quality of life, pre and postoperative, of 227 patients who were submitted to endoscopic thoracic sympathectomy after the diagnoses of primary hyperhidrosis. To analyse the changes in the individuals' emotional state, side effects and the incidence of compensatory hyperhidrosis in an easily manner, the authors decided to design and implement a BI system and analytic tools to store, handle and analyse data. Data collected from two available online questionnaires were firstly stored in data marts. After this, and to understand what stage of life of patients the hyperhidrosis emerges and the clinical manifestations with greater and lesser incidence of compensatory hyperhidrosis as a consequence of surgery, data were analysed from different perspectives through Online Analytical Processing technology. At the final stage, predictive models were built with data mining tools, enabling to identify the emotional state of patients for the occurrence of side effects and the degree of compensatory hyperhidrosis (Gonçalves, Santos and Cruz, 2010).

2.4 Summary

This chapter has presented the importance of managers have good control of an organisation, which can be achieved by measuring organisational performance against strategic objectives. Unlike most organisations, healthcare organisations make performance measurement a real challenge, given the absence of good measures of outputs and a tradition of inadequate management. However, healthcare organisations must be controlled. ISs play an important role to handle such challenge endeavour, by transforming data into accurate, reliable and timely information. Therefore, managers are

able to decide with basis on knowledge acquired by available information instead of subjective judgement, contributing to improve decision-making process.

This chapter has also provided a brief overview about the introduction of BI systems and analytical tools in ISs field in the last decades, where data-driven management gained a new impetus. These intelligence systems are capable to analyse large volumes of data from multiple sources in a real-time access, through a user-friendly interface. Recently, healthcare decision makers have noticed the capabilities of BI systems and analytical tools to guide their work, and improve managerial and clinical performance levels. This is corroborated by the main findings of the empirical studies presented in the ending of the chapter, where BI systems are being implemented in the healthcare organisations to overcome inefficiencies and help managers to make better and more informed decisions.

Chapter 3. CASE STUDY

3.1 Overview of the Portuguese Health System

3.1.1 Organisational structure

The PHS gave its first steps when the first social security law was enacted in 1946. However, it was only after the democratisation of Portuguese society in 1974 that the restructuring of health services began, ending in the establishment of the National Health Service (NHS) in 1979 (Barros, Machado and Simões, 2011; Simões, 2013).

The PHS is composed by three coexisting and overlapping systems: the NHS, universal and tax-financed system; public and private health insurance schemes (also known as health subsystems) for certain profession categories; and private voluntary health insurance. The tax payers play an important role in the Portuguese NHS, funding its activity to provide universal coverage to population (Simões, 2013).

On the top of the NHS's administrative structure is the Ministry of Health (MOH) since 1958, who is responsible for planning, regulating and managing the health system. To carry out its functions, the MOH and its institutions define a national health policy and objectives, through the National Health Plan and the National Strategy for Quality in Health, and evaluate its implementation (Barros, Machado and Simões, 2011).

At the regional level, the implementation of national health policy objectives is in the hands of the Regional Health Authorities (RHAs) (called *Administrações Regionais de Saúde*), which were established in 1993. Each of the five RHAs are also responsible for developing local strategic guidelines to provide and manage population healthcare needs, supervision and control hospitals and primary care, and contracting regional services with health institutions (i.e. hospitals, primary care and private sector) for NHS patients. The RHAs have only financial responsibility for primary care, since hospitals budgets are established and allocated centrally taking into account the annual government budget (Barros, Machado and Simões, 2011).

All hospitals belonging to the NHS are under the jurisdiction of the MOH, through RHAs. Along with RHAs, Administration of the Health System (ACSS) (called *Administração Central do Sistema de Saúde, IP*) is responsible for the definition of policy, regulation and planning of health, particularly in the national financial management model and contracting process with health institutions. This public organisation was established in 2007 and its functions are also concerned to the

management of financial and human resources, facilities and equipment, information and technology systems of the NHS (Barros, Machado and Simões, 2011).

3.1.2 Recent structural changes

In the late 1990s, the PHS developed several reform initiatives to improve the NHS in different areas of intervention: health promotion, long-term care, primary and ambulatory care, hospital management and inpatient care, and pharmaceutical market. Particularly at acute-care level, a number of reforms have been implemented in the last decades and are still ongoing processes (Barros, Machado and Simões, 2011; Simões, 2013; Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014; OECD, 2015).

The rationalisation and specialisation of hospital sector has been done by concentrating hospital services into fewer, larger hospital centres and groups (horizontal integration). The vertical integration started in 1999 with the creation of Local Health Units (called *Unidades Locais de Saúde)*, which integrates hospitals and primary care centres in the same geographical area. As a result, the number of hospitals at 634 in 1970 has dropped to 67 in 2008 ((Barros, Machado and Simões, 2011).

Starting from 2002, the transformation of some public hospitals (called *SPA* hospitals) into Incorporated Public Hospitals (called *Hospitais SA*) and later into Public Enterprises (EPE) (called *Entidades Públicas Empresariais*), as well as the development of public and private partnerships (PPP) (called *Parcerias Público-Privadas*), both in response to the introduction of new models of hospital management, gave more managerial, administrative and financial autonomy to hospitals. In 2014, there were six *SPA* hospitals, 38 EPE hospitals and four PPP (OECD, 2015).

Alongside the hospital status transformation, a new payment system has been implemented for NHS hospitals, based on negotiated CPs with an adapted diagnosis-related group (DRG) (called *Grupos de Diagóstico Homogéneo*) payment system. The negotiated contracts provided a clear separation between the purchaser and the provider of healthcare services. Each year hospitals have to commit to certain level of activities and a budget is allocated as a result of its annual performance. This budget is allocated to NHS public hospitals by the MOH through the ACSS within an activity-based prospective payment model involving systematic DRG grouping and case-mix adjustment for inpatient care and ambulatory surgery, where a price for each line of activity is negotiated between the hospital and the ACSS. This pay-for-performance system determines nearly 50% of the hospital revenue, while the remaining 50% of financing comes from fee-for

services (for outpatient and emergency visits) and bundled payments (for some chronic conditions) (45%), and institutional incentives concerned to quality and productivity outcomes (5%). Under these circumstances, performance indicators are systematically monitored and the NHS can apply penalties to hospitals which do not meet the contracted objectives (OECD, 2015).

Other hospital reforms have been undertaken in the last decades, such as: (i) introduction of generic drugs prescriptions; (ii) investing in more human resources (i.e. physicians and nurses); and (iii) developing of quality initiatives (e.g. quality and safety standards, electronic medical prescription, shared medical information, national accreditation system, among others) and its monitoring trough a quality-benchmarking project implemented by ACSS since 2013 (OECD, 2015).

The committed efforts on introducing reform initiatives demonstrates that Portugal is moving toward a more quality and efficient hospital system (OECD, 2015). However, these initiatives have been implemented in a slow and discontinuous manner (Barros, Machado and Simões, 2011; Simões, 2013; Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014). Difficulties in managing change in the healthcare sector is linked to poor information for decision-makers, lack of policy continuity, imposition of cost control measures, centralized command, limitations on good governance and influential of stakeholders over the common good (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014). Consequently, challenges do remain in PHS, particularly around the need to introduce more efficient clinical processes, improve the capacity of primary and long-term care, review institutional incentives system associated to hospital performance, and assess the impact of reforms on clinical outcomes and care standards (OECD, 2015).

All challenges that the PHS have been faced became greater since the beginning of the global financial crisis in 2007, where the Portuguese financial, economic and social situation has deteriorated greatly. Despite of a number of austerity measures implemented between 2009 and 2011, Portugal was unable to refine its foreign debt and was forced to request external assistance to the European Union and the International Monetary Fund. In May 2011, Portugal and the Troika signed a Memorandum of Understanding for a €78 billion loan in return to adopt an Economic and Financial Adjustment program (AP) (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

The AP included a set of austerity requirements for the period 2011 to 2014, such as reducing the budget deficit by decreasing public spending and increasing tax revenues, concentrating efforts on fiscal policy, stabilisation of the financial sector and implementation of structural reforms in a number of areas (i.e. labour, goods, services and housing). At healthcare sector, the objectives of the AP were to improve efficiency and effectiveness of the PHS, rationalising the use of health resources, reducing hospital operating costs and public spending on pharmaceuticals, and increasing revenues through user charges (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

Aside from general austerity and its implication on social determinants of health, the AP brought some positive measures to the PHS. Measures such as hospital mergers, pharmaceutical policies and increasing of generic prescribing have led to significant savings for NHS and patients (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

The hospital mergers' reform gained a new impetus, targeting a reduction by at least 5% of additional cuts in operating cuts for 2013. Besides that, new legislation was created in 2012 forbidding public authorities from incurring expenditure not covered in their approved budget and, therefore, forcing them to pay off all creditors within 90 days to prevent the accumulation of debts, under penalty of civil, criminal, disciplinary and financial responsibility (called *Lei dos compromissos e dos pagamentos em atraso das entidades públicas)* (Lei n.º 8/2012 de 21 de fevereiro[1]) (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

At pharmaceutical-level, despite of a reduction of €668 million spending on drugs covering the period 2010 to 2011, the AP forced an agreement between the MOH and the Portuguese Association of Pharmaceutical Industries in May 2012. The goal was to reduce public expenditure on drugs by €300 million in 2012 to guarantee the solvency of NHS, pay its debts to the pharmaceutical industry on due time and improve its access to new drugs (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

In addition to price cuts, it has been mandatory for physicians to use electronic prescription to publicly financed drugs and financed procedures since September 2011, as well as to prescribe generic drugs since June 2012. Moreover, at the beginning of 2013, Physicians, scientific societies and patient organisations were required to declare conflicts of interests in their interactions with the pharmaceutical industry (Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014).

[1] Law n.º8/2012, 21st of February

Table 4.1 summarises the historical background and recent reforms initiatives.

Table 3.1 Timeline of historical background and recent reforms in the PHS

18th century	Healthcare provided by the hospital of religious charities (called *Misericórdias*)
1946	Implementation of the first social security law
1958	Creation of the MOH
1974	Democratic revolution on April 25, after a long period of right-wing political dictatorship Healthcare sector financed mainly by public funds
1979	Establishment of the NHS Universal health system creation (free at the point of use)
1990	Beginning of structural reforms to improve the NHS
1993	Establishment of five RHAs
August 2002	Transformation of some public hospitals into EPE hospitals and development of PPP hospitals, both as a new model of hospital management
November 2002	Allocation of prospective global budgets with basis on CPs
2006	Establishment of family health units (primary care) and Long-term Care Network
2007	Creation of the ACSS Beginning of the global financial crisis
May 2011	Signing of Memorandum of Understanding between Portugal and the Troika
September 2011	Mandatory use of electronic prescription to publicly financed drugs and financed procedures by physicians
February 2012	Creation of "*Lei dos compromissos e dos pagamentos em atraso das entidades públicas"*
May 2012	Agreement between the MOH and the Portuguese Association of Pharmaceutical Industries to reduce public expenditure on drugs
June 2012	Mandatory prescription of generic drugs by physicians

February 2013	Mandatory declaration of interest conflicts between physicians, scientific societies and patient organisations in their interactions with pharmaceutical industry
October 2013	Implementation of quality-benchmarking project by ACSS

Source(s): Barros, Machado and Simões (2011); Simões (2013); Sakellarides, Castelo-Branco, Barbosa and Azevedo (2014); Lei n.º 8/2012, 21 de fevereiro; OECD (2015)

3.2 Background and history of the *São João* Hospital Centre, EPE

The SJHC (or *São João* Hospital, as designated at that time), was officially opened on June 24, 1959, and is one of the best leading university hospitals in the country (Hospital de São João, EPE, 2010). Recently has been ranked number one in the country for the years of 2013 and 2014, by the National Health Public School (Costa & Lopes, 2015a; Costa & Lopes, 2015b).

Located in Oporto, the SJHC is the largest public hospital in the northern region of Portugal and one of the largest in the country, offering a diverse range of services in medical and surgical specialties. It provides highly differentiated care for resident population in the communities of Bonfim, Paranhos, Campanhã and Aldoar, neighboring counties of the city (except Baião, Amarante and Marco de Canaveses) and districts of Porto, Braga and Viana do Castelo, covering a population of 3.700.000 people. Beyond northern region, the SJHC also serves other geographical areas in Portugal through the Hospital Referral Network (called *Rede de Referenciação Hospitalar)*. This usually happens under specific purposes, such as outpatient appointments in differentiated specialties or high complexity surgeries, both not provided by the referral hospitals (Centro Hospitalar de São João, EPE, 2011).

In recent years, the structural healthcare changes has also affected the SJHC's organisation. On December 31, 2005, the hospital has become an EPE hospital as part of a new model hospital management initiative (Hospital de São João, EPE, 2010). The rationalisation and specialisation of hospital sector contributed to the merger of the hospital and *Nossa Senhora Conceição Valongo* Hospital into SJHC on April 1, 2011. As a result, services of both hospitals were concentrated in the SJHC and became the referral hospital for the population of Valongo. Further, in response to the austerity crisis, the SJHC implemented a containment plan in 2011 to improve efficiency and reduce costs (Centro Hospitalar de São João, EPE, 2011).

In 2014, the SJHC had a capacity of 1044 beds for acute care, 43 cribs, 14 physical medicine and rehabilitation-inpatient beds and 12 psychiatric-inpatient beds. Other facilities included 35 operating rooms, five delivery rooms, 245 outpatient rooms and 146 outpatient day care beds and/or chairs (Centro Hospitalar de São João, EPE, 2014).

The core values of the SJHC are competence, humanity, passion, rigor, transparency, unity, solidarity and ambition. These values determine the SJHC's vision to be a national and international reference of excellence care, with basis on a sustainability growth, sense of change, commitment and differentiation, aiming to create value for stakeholders being a brand reference in the healthcare sector. The SJHC's mission is to deliver top-quality patient care, with high levels of competence, excellence and rigor, encouraging research, the principle of humanization and the sense of belonging of all professionals (Centro Hospitalar de São João, EPE, 2014).

The SJHC's administration structure is composed by a Board of Directors (President, Executive Members, Medical Director and Nursing Director), the Statutory Auditor and the Advisory Council. This structure also includes Technical Support Committees and Support Bodies (Centro Hospitalar de São João, EPE, 2014).

The strategic view of Board of Directors includes a model of decentralized middle management as a strategy to maximize resources and achieve high levels of efficiency, and internal contracting as a tool to ensure the best use of available financial resources. The managerial activity is divided into intermediate levels of management, structured by two complementary areas: Production and Support. The Production area is organised by Autonomous Management Units (called *Unidades Autónomas de Gestão)*, particularly in Surgery, Medical, Emergency and Intensive Medicine, Woman Clinic, Psychiatry and Mental Health, Paediatrics, Laboratorial Medicine and Imaging. The Support area is divided in responsibilities centres, such as: Ambulatory, Logistic, Business and Epidemiology (Centro Hospitalar de São João, EPE, 2014).

3.3 Business and Clinical Intelligence project *HVITAL*

In January 2012, the SJHC developed a project based on BI technology of Microsoft® in collaboration and partnership with a consultancy agency, called DevScope®, using an initial investment of €50.000. The main goal was to create a technologic platform capable of collecting, storing and analysing thousands of data in seconds, and transform it into information to support management and clinical decision-making (Centro Hospitalar de São João, EPE, 2012).

Before *HVITAL's* implementation, the SJHC had the same obstacle than other Portuguese hospitals to get access to information: data were stored in incompatible formats, being dispersed and disaggregated by different ISs, which do not communicated with each other. As a result, a massive amount of data could not be transformed into information and, therefore, it was not possible to have a holistic view of the organisation. This was a source of concern to the SJHC, since information for improving performance and make healthcare delivery more consistent and less costly was not either sufficient or available in a timely manner. To tackle this challenge, the SJHC decided to invest in a BCI project, called *HVITAL* (Cardoso, 2012).

Initially the project was named "BI" (from Business Intelligence) and later, in 2013, it was designated *HVITAL* as an abbreviation of "*VIgilância*, *moniTorização* and *ALerta*" (meaning "surveillance, monitoring and alert"). In 2012, the project Manager started to design algorithms focused on management KPIs. For monitoring clinical indicators, the algorithms were designed from 2013 and a pilot was initiated in two wards (surgery and internal medicine).

At the moment, the *HVITAL* collects and analyses in depth a huge amount of data of all organisation with basis on over 600 KPIs. Data that would take weeks or months to be gathered is now available in seconds or minutes, through a system able to upgrade millions of records per day. Information is available from the senior management to operational levels, ensuring that all users decide on the basis of the same numbers (Cardoso, 2012).

Over the recent years, the SJHC has gone through the same challenges than other Portuguese hospitals to improve quality and efficiency, and reduce costs. But unlike most of them, the SJHC has been achieving high levels of performance, year after year (Costa and Lopes, 2015a; Costa and Lopes, 2015b). Thus, and after two years of implementation, it seemed to be time to explore the impact of this project in the SJHC.

3.4 Research methodology

3.4.1 Research planning

3.4.1.1 Research strategy

Case study was chosen as the research method by the driving purpose of this study. Yin (2009: 18) refers to the case study as "an empirical enquiry that investigates a

contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". Case studies can offer important evidence in their ability to investigate a complex social phenomenon where behaviours cannot be manipulated, using "how" or "why" questions in relation to contemporary set of events. The purpose is to expand and generalise theories to theoretical propositions (analytic generalisation), and do not particularise to populations or universes by enumerating frequencies (statistical generalisation) (Yin, 2009).

Since the study aimed to find out what was happening in the SJHC, seeking insights about the impact of the *HVITAL's* project on the hospital performance, an exploratory case study was employed, given its ability to adapt to as the research proceeds (Saunders, Lewis and Thornhill, 2009).

A case study may include both quantitative or qualitative data, depending on what it is being investigated (Yin, 2009; Bryman, 2012; Pickard, 2013; Creswell; 2014). In this sense, the present research is based on positivist and interpretivist paradigm (Pickard, 2013). Mixed methods research are increasingly used in business and management research (Saunders, Lewis and Thornhill, 2009; Bryman, 2012), offering a better understanding of the phenomenon being studied than either quantitative or qualitative methodologies by itself (Creswell, 2014). Quantitative data provides useful information about trends, and qualitative data offers different perspectives about the phenomenon in study (Sunders, Lewis and Thornhill, 2009). Combining both methodologies is always challenging while doing a case study research (Yin, 2009), however, it seemed to be the best approach to the context.

The methodology employed took into account completeness purposes (Bryman, 2012), which means a more comprehensive description of the phenomenon in study. For such, and after perform the quantitative study, the qualitative approach was put in practice to clarify and get more detailed data about questions raised from the quantitative analysis or issues that this method was not able to fulfil by itself.

After the scope and the nature of the study be clarified, the research questions stated and the unit of analysis selected, the theoretical background was started. In first place, the study took into account different literature search strategies (Saunders, Lewis and Thornhill, 2009; Pickard, 2013; Creswell, 2014) to cover the literature review, which was performed with basis on authors of international renown in management control and ISs areas, as well as with the existing contributions of BI projects in the healthcare sector. After this, keywords were identified and different strings were assembled in a meaningful

way. Then, relevant academic studies in predetermined electronic databases were selected. The next step involved a critically evaluation of literature collected, concerning its relevance and accuracy. And finally, the theoretical background was written.

Data collection was made separately. First, quantitative data were collected from 2010 to 2014, such as annual reports and other secondary documents published and/or provided by SJHC. The years of 2010 and 2011 were set as the years of pre-implementation of the *HVITAL*, 2012 as the implementation year, and 2013 and 2014 the post-implementation years. Following this, qualitative data were gathered through semi-structured interviews. Creswell (2004) refers to this design as explanatory sequential mixed method. The rationale for this approach is that "the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture" (Creswell, 2014: 572). Both types of data, quantitative and qualitative, were collected with the SJHC's permission (Annexes A and B) and interviewees' informed consent (Annex C).

Concerning to data analysis, quantitative data were analysed using financial statement and contract programme analyses, and qualitative data by thematic analysis.

3.4.1.2 Sample selection

Sampling is a vital stage in the research process and should be appropriate to the research goals. In this exploratory case study, the sample was purposefully selected. The purposive sampling means intentionally choose individuals and/or a site to better understand the phenomenon (Saunders, Lewis and Thornhill, 2009; Pickard, 2013; Creswell, 2014).

The SJHC implemented a BCI project in January 2012, called *HVITAL*, aiming to do enhancements in collection and analysing internal information to improve decision making. Since then, the hospital has been distinguished with several awards highlighting the year of 2014, where SJHC was the first Portuguese institution to be internationally awarded with the "Microsoft Health Innovation Award" (Centro Hospitalar de São João, EPE, 2014). Furthermore, the SJHC was considered the best public hospital in Portugal for two consecutive years (2013 and 2014), by the National Health Public School (Costa and Lopes, 2015a; Costa and Lopes, 2015b).

After choosing the SJHC as the site of the phenomenon in study, 12 hospital professionals were purposely selected to share their perceptions about the impact of the

HVITAL's project on the hospital performance. The participants selection was made according to daily involvement with the *HVITAL*, functional areas (both in management and clinical areas), and availability to participate in the chosen dates for the interviews. This choice was made in collaboration with the *HVITAL's* project manager.

3.4.2 Data collection

3.4.2.1 Primary data

Primary data was collected by interviews. Interviewing is a useful way to gain insight of individual meanings, beliefs and feelings about a phenomenon (Arksey and Knight, 1999; Saunders, Lewis and Thornhill, 2009; Pickard, 2013). One reason to apply interviews was the fact that participants were more available to be interviewed rather than complete a questionnaire, according to the *HVITAL's* project manager. Further, interviews gave the opportunity to reach areas of reality that would otherwise remain inaccessible, getting more comprehensive explanations about the phenomenon in study by prompting and probing answers.

Interviews were designed considering the objective and questions of the study, the nature of the participants and the investigator's experiencing at interviewing. Relevant topics and themes to pursue were carefully chosen beforehand. An interview guide was also elaborated in advance (Appendix 1), serving as a framework for the main body of semi-structured interviews. The semi-structured interview generates qualitative data in a conversational manner, but at the same time provides the opportunity to pursue a line of inquiry with more well-established boundaries (Arksey and Knight, 1999; Saunders, Lewis and Thornhill, 2009; Pickard, 2013).

From 16 to 17 December 2015, 12 face-to-face semi-structured interviews were conducted. Each interview was approximately an hour in duration. Interviewees were free to answer the questions, prompts and probes' addressed in terms of their understanding about the impact of *HVITAL's* project in the SJHC, as well as ask for clarification or further elaboration. A set of questions was asked to all participants, and other questions were performed only for specific professionals, according to functional areas. Answers were recorded by two audio devices, with the informed consent of the interviewees (Annex C).

Table 3.4.2.1 presents a summary of interviewees by functional area.

Table 3.4.2.1 Interviewees by functional area

Managers		**Healthcare professionals**
Executive Administrator		Clinical Director of Orthopaedics service
Director of Planning and Control department		Head of Support Nursing Practices Office (called *Gabinete de Apoio às Práticas de Enfermagem)*
Manager of Medical Autonomous Management Unit (called *Unidade Autónoma de Gestão de Medicina*)	***HVITAL's* project manager**	Nurse of Support Nursing Practices Office (called *Gabinete de Apoio às Práticas de Enfermagem)*
Manager of Surgical Autonomous Management Unit (called *Unidade Autónoma de Gestão de Cirurgia*)		Head of Epidemiology Centre
Member of Supply and Logistics' team		Head of Unit for Prevention and Control of Infection and Antimicrobial Resistance (also known as *UPCIRA*)
Director of Clinical Audit		

Source(s): Self-elaboration

Three distinct groups of participants were identified: managers, *HVITAL's* project manager, and healthcare professionals. First, managers, which work involves accessing information that has been provided by someone else for decision-making purposes. Second, *HVITAL's* project manager, who implemented the project and supports informatics needs of managers and healthcare professionals, being the bridge between them and the *HVITAL*. Third, healthcare professionals, which are responsible for produce and analyse healthcare information to carry out efficiently and effectively clinical decisions, but does not play a decision-making role on management issues.

3.4.2.2 Secondary data

Secondary data include both quantitative and qualitative data and is often do as part of case studies about a particular organisation (Saunders, Lewis and Thornhill, 2009; Yin, 2009). According to Zikmund (2000, p. 124), secondary data are "data gathered and recorded by someone else prior to (and for purposes other than) the current need of the researchers". Zikmund (2000, p. 124) adds that secondary data "are usually historical, already assembled, do not require access to respondents or subjects". According to Richie and Lewis (2003), secondary analysis implies use data for historical comparison, examine a particular part of the data set, or to achieve a different theoretical perspective.

Secondary data is commonly used in researches that also use primary data collection methods and can take many forms, such as written documents (e.g. books, notices, correspondence, minutes of meetings, reports to shareholders, transcripts of speeches, and administrative and public records) and non-written materials (e.g. voice and video recordings, pictures, drawings, films) (Saunders, Lewis and Thornhill, 2009). In this research, written documents were used as the main source of secondary data. Some of the organisational documents were available in published form, such as annual reports and press releases, other were provided by the SJHC give its overall value for the research (e.g. some of the CPs' results non-available in annual reports and other privilege information about the *HVITAL*'s project).

3.4.3 Data analysis

3.4.3.1 Quantitative data analysis

3.4.3.1.1 Financial statement analysis

Financial statements provide the basic information used for financial control an organisation. According to Subramanyam and Wild (2009) there are several tools designed to analyse the two most important financial statements – the balance sheet and the income statement. Among the different tools, the common-size financial statement analysis and ratio analysis were used.

Creating common-size financial statements helps to set-up a proportion of a group or subgroup in relation to a particular account (Subramanyam and Wild, 2009). It is a useful tool to restatement financial statements' information in a standardised form and compare it over time (Robinson, Greuning, Henry and Broihahn, 2009). In the balance

sheets' analysis all accounts were stated as a percentage of total assets, where total assets were expressed as 100%. In the income statements' analysis net revenues were set at 100%, with the remaining accounts expressed as a percentage of net revenues.

Ratios are "a useful way of expressing relationships between financial accounts and expected relationships from one point in time to another" (Robinson, Greuning, Henry and Broihahn, 2009: 265). In this sense, the financial ratios analysis enables to gauge the financial and economic performance of an organisation. Since there are no authoritative bodies specifying for a standard in ratios calculation, they were computed with basis on Robinson, Greuning, Henry and Broihahn (2009).

3.4.3.1.2 Contract programme analysis

The negotiated CPs between hospitals and the RHAs are useful tools to analyse performance levels, since hospitals have to commit to certain level of activities (i.e. objectives) in return for a budget (OECD, 2015). On that basis, the SJHC's performance was analysed by comparing the CPs from the period of 2010 to 2014. Note that, instead of analysing both production objectives and quality's and efficiency objectives, the analysis was only performed with the second ones. This choice was made due the fact of production objectives were not complete enough to be submitted to a rigorous analysis, as can be seen by Appendix 2.

To compare the SJHC's performance through the results of quality's and efficiency objectives, the indicators included in the contract signed for 2014 (Appendix3) were used as a model for all the years under scrutiny (Appendix 4). This decision was made aiming to normalise the analysis, i.e. using comparable indicators for the five years under analysis, since some of indicators have been changing year after year, as can be seen by comparing Appendixes 3,5,6,7 and 8. All indicators presented in Appendix 4 were submitted to comparison, with exception of those with non-available information before and after the implementation of the *HVITAL*'s project (i.e. exclusion criteria applied for those indicators presenting available data just before 2012 or after 2012).

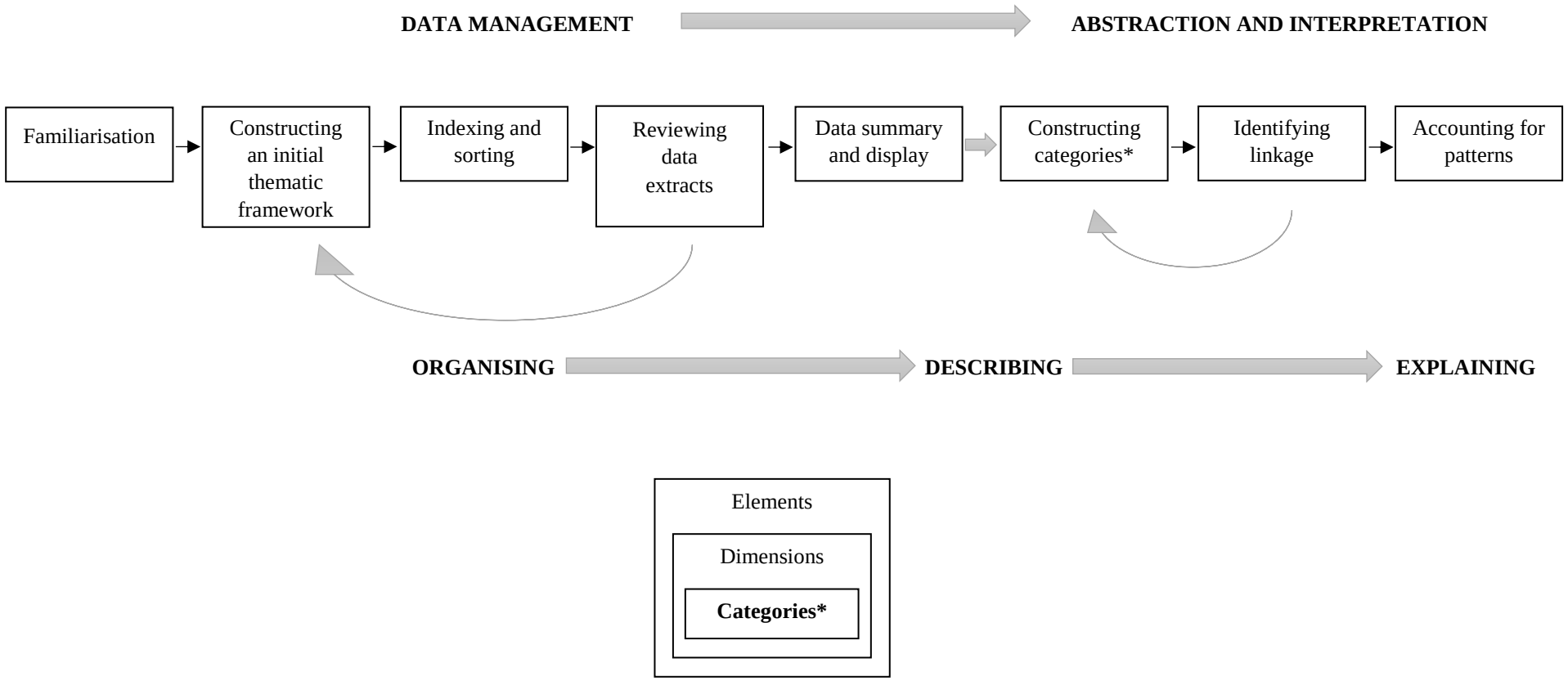
3.4.3.2 Qualitative data analysis

To analyse the qualitative data in a systematic and iterative manner, a thematic analysis was employed using Framework approach (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014; Spencer, Ritchie, O'Connor, Morrel and Ormston, 2014). According to the authors, this systematic approach is specifically used in relation to

textual data, focusing on interview transcripts in particular, and the steps employed makes the data manageable, enabling an easier access and interpretation.

As presented by Figure 3.4.3.2, the Framework approach process is divided into two broad stages: data management, and abstraction and interpretation.

Figure 3.4.3.2 – Design of Framework approach process



Source(s): Spencer, Ritchie, Ormston, O'Connor and Barnard (2014)

Data management relates "to the process of making qualitative data "manageable"; of labelling and sorting the data according to a set of themes or concepts in preparation for more interpretive analysis" (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014: 282). The process of data management involves labelling, sorting and reassembling data in five key steps, as shown by Figure 3.4.3.2 and explained as follows. At the beginning of the process all interviews were transcribed verbatim into a Word® document, and the material was carefully reviewed to get an overview of the data coverage (familiarisation). By getting familiarised with the transcripts, key topics and subjects of interest were identified to label, sort and compare the data, according to the objective of the research, sample, research questions and interview guide. Once the list of topics was reviewed, a set of themes and subthemes were sorted in order to construct an initial thematic framework. In respect to the third step (indexing and sorting), data were labelled according to the themes and subthemes sorted out to the thematic framework. After this, data extracts were reviewed for coherence and further refinement of the initial thematic framework, and a final analytical framework was drawn up (Appendix 9). A final step of data management in some thematic approaches involves data summary and display. Although some researchers do not follow it, the data summary and display step was performed in the present study aiming to reduce the amount of data to a more manageable level. In this sense, a number of thematic matrices were created, each relating to a different theme from the thematic framework. Each theme was arranged in a matrix. Subthemes were represented by columns while the individual participants by rows. Data from each interviewee were summarised into the appropriate cell, enabling an easy access and analysis of the themes, as well as its comparison between individuals' perceptions (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014; Spencer, Ritchie, O'Connor, Morrel and Ormston, 2014). Given the time required to translate data from all created matrices (i.e. from Portuguese to English), Appendix 10 presents only one of them.

Abstraction and interpretation refers to "tease out what will become the main findings of the research" (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014: 284). The process of abstraction and interpretation is a more interpretive phase than data management, and involves categorising the data in two key steps: (1) the description step, involving the development of categories (Table 3.4.3.2); and (2) the identification of linkage between them. Elements, key dimensions and categories were designed according to the themes emerged from the primary data, as well as the theoretical background

(Appendix 11). The linkage was made with basis on attachment subgroups, which means to explore the links between the phenomenon and the perceptions of particular subgroups (in this case with basis on functional areas). Second, the explanation step, in which explicit and/or implicit explanations were developed, in order to make logical sense of patterns within the data under scrutiny (Spencer, Ritchie, Ormston, O'Connor and Barnard, 2014; Spencer, Ritchie, O'Connor, Morrel and Ormston, 2014).

Table 3.4.3.2 – Categories

Reasons of implementation
Operationalisation
Management outcomes
Clinical outcomes
Organisational culture influences
Modifications
Development of new analytical tools

Source(s): Self-elaboration

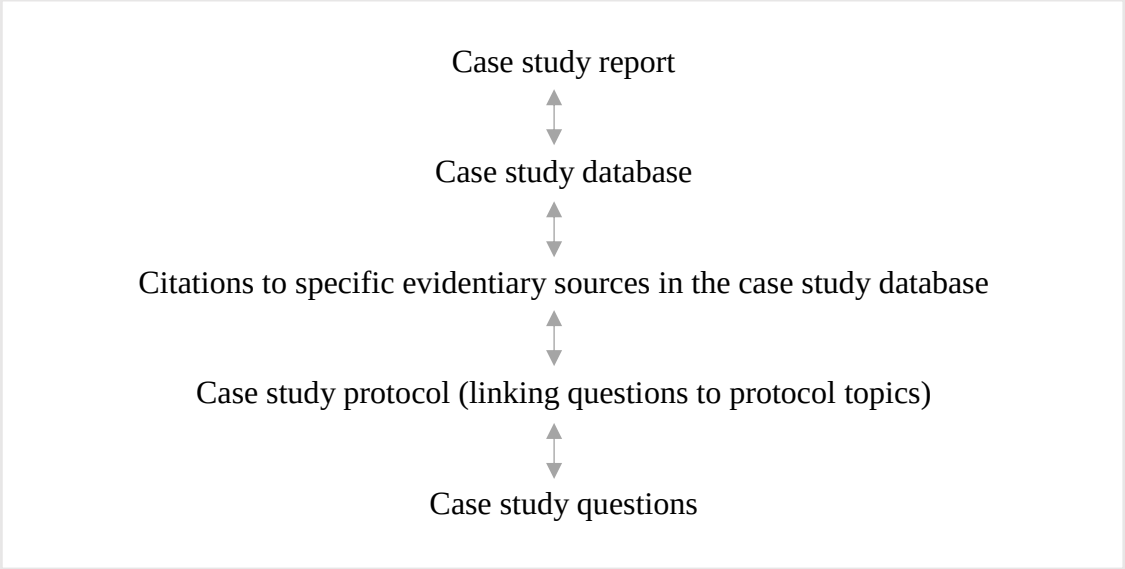
3.4.5 Validity and reliability criteria

Yin (2009) supports the application of four tests to judge the quality of the research design: validity, internal validity, external validity and reliability.

To construct validity during the data collection procedure, multiple sources of evidence were used (i.e. documentary data and interviews), as well as a chain of evidence, as shown by Figure 3.4.5 (Yin, 2009).

Concerning to external validity, a holistic single-case study was chosen. Despite of single cases provide a poor basis for generalising, they are the best approach to study revelatory or unique cases, which means the opportunity to analyse a real-life situation that has not been able to be study in the past. In the same vein, the holistic design may be more abstract than the embedded design, however, it was intention of this study to capture the entire case (i.e. organisation) as a whole. Regarding to internal validity, it is tested for explanatory case studies, not being suitable to be tested in the present research (Yin, 2009).

Figure 3.4.5 – Chain of evidence



Source(s): Yin (2009)

In the case of reliability, the emphasis is to demonstrate that procedures followed in the case study can be repeated by another researcher to achieve the same results. In such a case, the main goal is to minimise the error and bias in a research (Yin, 2009). According to the author, there are two specific prerequisites to overcome these shortcomings – a case study protocol (Appendix 12) and a case study database, which were both met on this study.

3.5 Research findings

3.5.1 Quantitative findings

A number of issues must be considered when performing a financial statement analysis to the financial accounts of the SJHC. First, the merger of SJH and *Nossa Senhora Conceição Valongo* Hospital into SJHC affected the financial statement report for 2011, which were just elaborated taking into account the period of time between April 1 and December 31. Second, the global financial and economic crisis have led to the implementation of a containment plan in 2011, to improve efficiency and reduce costs. Third, new legislation was created in 2012 – "*Lei dos compromissos e dos pagamentos em atraso das entidades públicas*" – (Lei n.º 8/2012, 21 de fevereiro[2]) –, with impact on the average number of days that the SJHC takes to pay its suppliers. Fourth, the ACSS

[2] Law n.º 8/2012, 21st of February

implemented a quality-benchmarking project in 2013 to monitor national hospitals. Finally, the introduction of new production lines without defining the billing rules within the CP by ACSS in 2013 contributed to the hospital failed to carry out the regular billing on due time.

3.5.1.1 Common-size financial statement analysis

The balance sheet is one of the most important sources of financial information. In effect, it provides information about the relative amounts of assets, liabilities and equity, disclosing the financial position of an organisation at a particular point in time (Swayne, Duncan and Ginter, 2008; Robinson, Greuning, Henry and Broihahn, 2009). Thus, the SJHC's common-size balance sheet key figures for the period 2010 to 2014 is presented below:

Table 3.5.1.1.1 Balance sheet key figures (common-size analysis)

	2010	2011	2012	2013	2014
Total assets	100%	100%	100%	100%	100%
Noncurrent assets	34%	19%	26%	16%	33%
Current assets	66%	81%	74%	84%	67%
• Short-term receivables	39%	29%	41%	11%	33%
Equity	52%	26%	38%	25%	53%
Liabilities	48%	74%	62%	75%	47%
• Short-term debts	33%	67%	50%	67%	31%

Source(s): Self-elaboration

As can be seen, most of the assets under management by the SJHC are current assets, i.e. assets that should, in principle, be transformed into cash in the short-run. In fact, the lowest figure for current assets as percentage of total assets is 66% in 2010. In the same vein, Table 3.5.1.1.1 shows that an important percentage of the SJHC's current assets are actually short-term receivables.

Table 3.5.1.1.1 also illustrates that there is a considerable variation on how SJHC finances its assets. In particular, in the first available year, equity represents 52% of total assets. Put differently, the hospital's main shareholder (i.e. the Portuguese government) invested 52 cents for each euro of assets the hospital had under management. One year later, this figure falls to only 26 cents per euro. Yet, in 2014, which is the last year with available data, one can see that equity finances 53% of assets in the SJHC. It is also important to stress that the equity of the SJHC never falls to negative figure within the period under scrutiny. This is an important issue since many other publicly owned

hospitals at Portugal do face this situation and some of them for several years now. Generally speaking, an organisation with negative equity is hardly of interest to its shareholders since, at book value, liabilities exceed the value of assets. When dealing with publicly owned hospitals this is translated into a poor financial structure, which tends to demands extra investment from the taxpayers to turn around.

As can be seen by Table 3.5.1.1.1, a considerable variation in the weight of the short-term liabilities relative to total assets. In the two worst years available, 2011 and 2013, short-term liabilities represented 67% of total assets. In other words, the SJHC had to use 67 cents of capital arising from a third party to finance each euro of assets it was managing. This is clearly a troublesome financing structure since, in general, short-term liabilities must be repaid in one-year time relative to the balance sheet date. Yet, in the best year available, 2014, one can see that the SJHC had only to use 31 cents of capital from a third party to finance each euro of assets it was managing.

Finally, looking at the available data, one is hardly be able to see any impact from the implementation of *HVITAL* on the SJHC's balance sheet structure. In fact, both the mix of assets and of sources funds of the hospital are too volatile, which precludes any type of serious consideration on that front.

Likewise the balance sheet, the income statement is one of the most important sources of financial information, communicating the organisation's performance over a period of time. In effect, it provides information about the revenue generated by an organisation and what costs it incurred by generating that revenue (Robinson, Greuning, Henry and Broihahn, 2009). Thus, the SJHC's common-size income statement key figures for the period 2010 to 2014 is presented below:

Table 3.5.1.1.2 Income statement key figures (common-size analysis)

	2010	**2011**	**2012**	**2013**	**2014**
Net revenue (operational)	100%	100%	100%	100%	100%
Cost of sales	96%	96%	96%	96%	95%
• Cost of goods sold	35%	38%	36%	35%	35%
• External supplies and services	11%	12%	12%	12%	12%
• Cost of labour	50%	45%	48%	49%	48%
EBITDA	3,98%	4,34%	3,63%	3,58%	4,84%
EBIT	0,47%	0,34%	0,003%	0,47%	0,45%
Financial income	0,15%	0,27%	0,43%	0,34%	0,38%
Nonrecurring income	-0,50%	-0,50%	-0,05%	-0,77%	0,56%
Net income	0,11%	0,07%	0,31%	0,04%	1,38%

Source(s): Self-elaboration

As can be seen by Table 3.5.1.1.2, the cost of sales has remained roughly stable in period under scrutiny. Cost of goods sold as a percentage of sales is also very stable within such period, as is the annual figures for external supplies and services. Cost of labour as a percentage of sales is a bit more volatile in the period but not to a big extent.

Table 3.5.1.1.2 also shows that earnings before interest, taxes, depreciation and amortization (EBITDA) of the SJHC never falls to negative values within the five years under analysis, peaking in value in 2014. This is important since many other publicly owned hospitals in Portugal do, unfortunately, face this situation. Moreover, the same Table shows that the SJHC remains economically sound in the five years under analysis even after amortizations and depreciations are considered. In fact, earnings before interest and taxes (EBIT) is always positive in the period. There is, however, considerable volatility in the yearly figures of EBIT. In particular, in 2012, EBIT as percentage of net revenue falls to its lowest value (0,0003%) and bumps to its highest figure in the next year (0,47%).

As the "bottom line" of income statement, the net income represents one of the most relevant accounts to describe an organisation's performance over a period of time. Table 3.5.1.1.2 shows that there is a considerable variation in SJHC's net income. In particular, in the first available year, net income represents 0,11% of net revenue. This means that the hospital is gaining 0,11 cents for each euro of sales (i.e. mostly in services rendered). One year later, this figure falls to only 0,07 cents per euro. In 2012, this figure increases to 0,31 and then reaches its lowest figure in 2013 (0,04%). Yet, in 2014, which is the last year with available data, one can see that net income represents 1,38% of net revenue.

Finally, looking at the available data, one is hardly to consider any impact from the implementation of *HVITAL* on the SJHC's income statement structure. In fact, despite the *HVITAL's* implementation in 2012, there were other effects described earlier that may also have had an impact on the SJHC's financial performance.

3.5.1.2 Ratio analysis

Ratios are used to better understand many relevant aspects of organisational performance (Robinson, Greuning, Henry and Broihahn, 2009). Ratios come in many different forms and shapes. As such, a handful of computed ratios is presented below, expressing the general performance of the SJHC in the period from 2010 to 2014.

The first set of ratios deal with liquidity. According to Robinson, Greuning, Henry and Broihahn (2009: 277) such ratios "measure the company's ability to meet its short-term obligations". Thus, these ratios can be used to learn how rapidly assets are converted into cash in order to pay current liabilities (Robinson, Greuning, Henry and Broihahn, 2009).

Three different liquidity ratios were used in this analysis. The first is the current ratio (CR), defined as the ratio between current assets and liabilities. In this case, higher ratio level indicates a higher level of liquidity, and is usual to consider that a value exceeding 1.0 is good practice. The second is the quick ratio, which is more conservative than the CR as it includes only more liquid current assets (i.e. cash, short-term marketable investments and receivables). The third and last liquidity ratio considered is the acid-test ratio. It is even more demanding than the quick ratio, as it uses only marketable short-term investments and cash as current assets (Robinson, Greuning, Henry and Broihahn, 2009).

Table 3.5.1.2.1 Liquidity ratios

	2010	**2011**	**2012**	**2013**	**2014**
Current ratio	1,38	1,09	1,20	1,11	1,41
Quick ratio	1,27	1,06	1,16	1,09	1,33
Acid-test ratio	0,13	0,02	0,10	0,03	0,08

Source(s): Self-elaboration

The table above summarises the results of computing these three liquidity ratios for the SJHC in the period from 2010 to 2014. All data was collected from the hospital's annual balance sheets. As can be seen, the SJHC's CR always stays above 1.0 in the period under analysis, peaking in value in 2014. As such, in general, one can conclude that the hospital seems to manage its current assets wisely in the sense that they are always more than enough to pay off all existing current liabilities in the five years considered. Moving on to the quick-ratio, one can see that it also is always higher than 1,1 in all years in display. This suggests that SJHC's managers care about liquidity since they manage their assets in order to be able to pay off their short-term liabilities with only cash, short-term marketable investments and receivables.

Finally, Table 3.1.5.1.2.1 shows a considerable volatility in the level of the acid-test ratio between 2010 and 2014. In fact, the lowest value for this ratio is 0,02 (in 2011) and the highest value is 0,13 (in 2010). Importantly, Table 3.1.5.1.2.1 suggests that the

implementation of *HVITAL* does not have a major impact on the hospital's liquidity levels. In particular, without any formal testing, the data available on this issue indicates that the hospital's liquidity level (as measured either by the CR, the quick ratio or the acid-test) is similar pre- and post-2012.

The second set of ratios deal with activity. According to (Robinson, Greuning, Henry and Broihahn (2009: 278), such ratios "measure how efficiently the company utilizes assets" (Robinson, Greuning, Henry and Broihahn, 2009: 278). Thus, these ratios can be used to know how efficiently an organisation manages its activities or, in other words, its assets (Robinson, Greuning, Henry and Broihahn, 2009).

A number of activity ratios are used in this analysis. The first is inventory turnover, defined as the ratio between cost of goods sold and inventory. In this case, higher ratio level indicates a shorter period that inventory is held. The second ratio is days of inventory on hand (DOH), defined as the ratio between the number of days in period (i.e. 365 days) and inventory turnover. Clearly, both inventory turnover and DOH are connected: the higher the inventory turnover ratio, the lower the DOH. In this case, a high inventory turnover means highly effective inventory management. The third ratio is the days of sales outstanding (DSO), defined as the ratio between the number of days in period (i.e. 365 days) and receivables turnover. To calculate the DSO ratio, it was necessary to compute the receivables turnover ratio first, as the ratio between revenue and average receivables. The ideal number of DSO is to collect outstanding receivables the quickly as possible. The fourth ratio is the days payables outstanding (DPO), defined as the ratio between the number of days in period (i.e. 365 days) and payables turnover. Similarly to DSO, DPO ratio's values were achieved after compute the payables turnover ratio, defined as the ratio between the purchases and average of trade payables. In this case, the ideal number of DPO should be a management decision and should be considered the industry specific features. The fifth and last activity ratio considered is working capital turnover. This ratio measures how efficiently the organisation generates revenue with basis on its working capital. Thus, a higher ratio indicates greater efficiency (Robinson, Greuning, Henry and Broihahn, 2009).

Table 3.5.1.2.2 Activity ratios

	2010	2011	2012	2013	2014
Inventory turnover	9	8,46	13,59	13,78	13,89
DOH (days)	43	43	27	26	26
Receivables turnover	3,06	2,29	2,48	n/a	n/a
DSO (days)	119	159	147	n/a	n/a
Payables turnover	2,04	1,24	1,11	2,23	4,87
DPO (days)	179	294	330	164	75
Working capital turnover	6,52	6,96	7,24	7,06	6,78

Source(s): Self-elaboration

The table above summarises the results of computing the activity ratios for the SJHC in the period from 2010 to 2014. All data was collected from the hospital's annual balance sheets and income statements. As can be seen, SJHC's inventory turnover has been increasing since 2011, peaking in value in 2014 (13,89). This is an indicator that the SJHC is being increasingly effective in the way it manages its inventory. In the same vein, the DOH ratio decreased from 43 days (in 2011) to 26 days (in 2014).

Table 3.5.1.2.2 also shows a considerable variation on how SJHC collects cash from clients. In particular, in the first available year, DSO ratio is 119. One year later, this value decreases to 159 days. In 2012, which is the last year with available data, the ratio decreases again to 147 days. The same Table shows that, over time, the SJHC has been improving the time it takes to pay off its creditors. In the first year with data available, the SJHC takes, on average, 179 days to pay its creditors. Two years later, i.e. in 2012, this value peaks to 330 days. Yet, in 2014, which is the last year with available data, one can see that the DPO is only 75 days. In the same vein, the payables turnover ratio increased since 2011 (2,04) to 4,87 (in 2014), which means that the SJHC is paying its creditors almost 5 times in a year. Table 3.5.1.2.2 also shows for each euro of working capital invested, the SJHC generates an average of 7€ of revenue in all the five years we consider. This is, to some extent, a reasonable pattern. Table 3.5.1.2.2 also shows for each euro of working capital invested, the SJHC generates an average of 7€ of revenue in all the five years considered. This is, to some extent, a reasonable pattern.

Finally, it is not possible to establish a causal relation between the implementation of the *HVITAL's* project and the SJHC's operational performance, given the existence of other possible causes for this fact. Though looking at the available data and without any formal testing, one can see that the SJHC is managing its activities efficiently, and even more from 2012 onwards.

The third set of ratios deal with solvency. Such ratios "measure the company's ability to meet its long-term obligations" (Robinson, Greuning, Henry and Broihahn, 2009: 277). Thus, these ratios are useful to assess the organisation's ability to satisfy debt obligations, as well as the adequacy of earnings and cash flow to cover interest expenses and other fixed charges (Robinson, Greuning, Henry and Broihahn, 2009).

Since publicly owned hospitals are financed by taxpayers, only two solvency ratios were used in this analysis. The first is the solvency ratio, defined as the ratio between equity and liabilities. This ratio is a comprehensive measure of solvency and determine whether an organisation can stay solvent. The lower its value the greater the probability that the organisation will default on its debt obligations. The second is the shareholder equity, defined as the ratio between total equity and total assets. In this case, the ratio ranges from 0 to 100%, where higher ratio level indicates a higher level of autonomy over debt capital (Robinson, Greuning, Henry and Broihahn, 2009).

Table 3.5.1.2.3 Solvency ratios

	2010	**2011**	**2012**	**2013**	**2014**
Solvency	108%	35%	62%	33%	112%
Shareholder equity	52%	26%	38%	25%	53%

Source(s): Self-elaboration (2015)

The table above summarises the results of computing the solvency ratios for the SJHC in the period from 2010 to 2014. All data were collected from the hospital's annual balance sheets. As can be seen, there is a considerable variation on how SJHC stays solvent. In the worst year available, 2013, the SJHC's solvency ratio was 33%, showing signs of vulnerability to meet its obligations when compared with 2010 (108%) or 2014 (112%). Table 3.5.1.2.3 also illustrates a considerable volatility on the shareholder equity ratio for the available years. Particularly, in the first available year, shareholder equity is 52%. Three years later, in 2013, the ratio shows a decrease to the lowest value of all years under analysis (25%). Yet, in 2014, which is the last year with available data, one can see that the shareholder equity is 53%. This ratio gives a clear idea about the wealth of the hospital.

Finally, Table 3.5.1.2.3 suggests that the implementation of *HVITAL* does not have a major impact on the SJHC's solvency levels. In particular, without any formal testing, the data available on this issue indicates that the hospital's solvency level is similar pre- and post-2013.

The last set of ratios deal with profitability. Such ratios "measure the company's ability to generate profitable sales from its resources (assets)" (Robinson, Greuning, Henry and Broihahn, 2009: 277). Thus, these ratios reflect the organisation's ability to manage expenses in order to generate profit on invested capital and, therefore, organisation's overall value.

A number of profitability ratios are used in this analysis. The first is the gross profit margin, defined as the ratio between gross profit and revenue. It measures the percentage of revenue required to cover operating expenses that have direct financial implications. The second is the operating profit margin, defined as the ratio between the operating income and revenue, which measures how economically efficiently an organisation is. The third is non-operating profit margin, defined as the ratio between non-operating revenue and operating revenue (where the non-operating revenue are financial income and nonrecurring income). The fourth is net profit margin, defined as the ratio between the net income (with recurring and nonrecurring items) and revenue. The fifth and last ratio considered is the EBITDA margin, defined as the ratio between EBITDA and revenue. This ratio is a good indicator of an organisation's economic health, since it evaluates performance without taking into account the impact of financial and accounting decisions or the peculiarities of the tax environment. Generally speaking, the interpretation of these five ratios are similar: higher values indicate higher profitability.

Two additional ratios area used to look at the return on the investment made on the hospital. The first is return on assets (ROA), defined as the ratio between the net income and total assets. In this case, the higher the ratio, the higher the income generated by a given level of assets. The second is return on equity (ROE), defined as the ratio between operating income and total assets. In this case, the higher the ratio, the higher the income generated by a given level of equity. These ratios are important profitability measures for evaluating how effectively and efficiently an organisation's management is managing its assets, and therefore the capital that shareholders entrust to it (i.e. tax payers) (Robinson, Greuning, Henry and Broihahn, 2009).

Table 3.5.1.2.4 Profitability ratios

	2010	**2011**	**2012**	**2013**	**2014**
Return on sales:					
Gross profit margin	62%	59%	60%	62%	62%
Operating profit margin	0,50%	0,36%	0,003%	0,51%	0,49%
Non-operating margin	1,06%	0,99%	1,61%	0,94%	1,21%
Net profit margin	0,12%	0,07%	0,35%	0,04%	1,50%

EBITDA margin	4,26%	4,62%	4,01%	3,87%	5,27%
Return on investment:					
ROA	0,14%	0,03%	0,30%	0,03%	1,97%
ROE	0,26%	0,13%	0,80%	0,11%	3,74%

Source(s): Self-elaboration

The table above summarises the results of computing the profitability ratios for the SJHC in the period from 2010 to 2014. All data were collected from the hospital's annual income statements. As can been seen, the SJHC's gross profit margin has maintained a stable level in the five years considered. In fact, the lowest value for this ratio is 59% (in 2011) and the highest is 62% (in 2010, 2013 and 2014).

Table 3.5.1.2.4 also shows a considerable variation on SJHC's operating profit margin. In particular, in the first available year, operating profit margin is 0,50%. This means that SJHC is gaining 0,005 cents (before interest and taxes) for each euro of services rendered. Two years later, in 2012, the SJHC has the lowest operating profit margin in all the five years (0,003%). Yet, in 2013, one can see that operating profit margin increases to 0,51%, which indicates improvements on how SJHC controls operating costs. Moving on non-operating profit margin, one can see that this ratio is higher than operating profit margin for all years under scrutiny, peaking in value in 2012 (1,61%). This suggests an alternative way of SJHC's increasing revenue to pay its operational and other expenses, given the challenges imposed by the budget constraints with the financial and economic crisis.

Table 3.5.1.2.4 also illustrates a considerable volatility on net profit income. In the first available year, the net profit income is 0,12%. In other words, the SJHC's gained 0,0012 cents for each euro of invested capital. Three years later, 2013, this value falls to only 0,0004 cents of revenue per euro invested. Yet, in 2014, which is the last year with available data, one can see that SJHC is gaining 1,50 cents for each euro of capital invested. Despite of this variation on net profit income, it is important to stress that before interest, taxes, depreciation and amortization, the SJHC presents a more stable level of profit. This is a result of EBITDA margin computation, which minimises the non-operating effects of depreciation and amortization recognition and taxes. As can been seen, the lowest EBITDA margin ratio is 3,87% (in 2013) and the highest is 5,27% (in 2014).

At the point view of return on investment, as can be seen by Table 3.5.1.2.4, there is also a considerable variation on how the SJHC generates more income using assets and

shareholders' money. In particular, in the first available year, the ROA is 0,14%. One year later, this value falls to the lowest ROA ratio in the five years under analysis (0,03%). In 2012, this value increases to 0,30% and then reaches once again 0,03% in 2013. Yet, in 2014, which is the last year with available data, one can see that ROA is much higher than in the other years under scrutiny (1,97%), In the same vein, the ROE is 0,26% in the first available year. One year later, this value falls to 0,13%. In 2012, this value increases to 0,80% and then reaches the lowest ROE ratio in the five years under analysis (0,11%). Yet, in 2014, ROE is considerable higher when compared with other years (3,74%). Thus, both ratios are indicating that in 2014 SJHC improved its ability to generate more income using its assets and equity capital.

Finally, looking at the available data, one is hardly able to see any impact from the implementation of the *HVITAL* on the SJHC's profitability. In fact, under such profitability ratios variations it is hard to preclude any type of serious consideration on that front.

3.5.1.3 Contract programme analysis

Table 5.7 summarises the results of quality's and efficiency objectives for the SJHC in the period from 2010 to 2014. All data were collected from the annual reports and other secondary data sent by the hospital.

Table 3.5.1.3 Results of quality's and efficiency objectives (2010-2014)

	2010	2011	2012	2013	2014
National objectives (60%)					
A. Access					
A.1. Percentage of first medical outpatient visit in the total of medical visits	23,1%	23,6%	25,0%	25,8%	26,1%
A.2. Percentage of patients referred for outpatient at the adequate time	n/a	n/a	65,7%	78,0%	78,4%
A.3. Percentage of outpatients discharged in the total outpatients visits	n/a	n/a	n/a	8,9%	11,3%
A.4. Percentage of surgical patients treated in a timely manner	n/a	n/a	97,1%	99,2%	99,1%
A.5. Inpatients referred to the Long-term Care Network in a timely manner	540	430	431	696	784
B. Clinical performance					
B.1. Average length of stay (days)	8,07	7,94	8,01	7,96	7,71
B.2. Percentage of readmissions within 30 days	n/a	n/a	8,0%	8,6%	7,9%
B.3. Percentage of patients with a length of stay above the maximum threshold	n/a	n/a	1,1%	1,2%	1,0%
B.4. Percentage of hip fractures with surgery performed within 48 hours of admission	n/a	n/a	n/a	n/a	66,1%
B.5. Percentage of day case surgery in total elective surgeries (among surgical procedures that can be performed in day-case setting)	49,06%	51,3%	54,5%	73,2%	77,1%
B.6. Percentage of generic medicines prescribed	n/a	30,4%	34,2%	36,2%	36,5%
B.7. Percentage of surgeries where the Surgical Safety Checklist has been used	n/a	n/a	n/a	95%	98,6%
C. Economic and financial performance					
C.1. Percentage of spending on overtime, supplements, and sub-contracting in the total personnel expenses	n/a	n/a	19,9%	13,7%	12,1%
C.2. Reporting a positive or null earnings before interest, taxes, depreciation, and amortization (EBITDA) (%)	13,7%	11%	11,7%	11,4%	15,9%
C.3. Growth of debts overdue	n/a	n/a	n/a	<=0	<=0

C.4. Percentage of extra operating income to that it was signed in total operating income	n/a	n/a	25,6%	13,02%	11,4%
Regional objectives (40%)					
D.1. Length of time for outpatient screening (days)	1092	1227	365	21	11
D.2. Starting of diabetic retinopathy treatment within 30 days	n/a	n/a	n/a	<=30 dias	<=30 dias
D.3. Referral rate for long-term care network	n/a	n/a	n/a	n/a	n/a
D.4. Outpatient/emergency ratio	n/a	n/a	2,3%	2,4%	2,6%
D.5. "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded	n/a	10,1%	10,1%	11,1%	9,5%
D.6. Palliative care	n/a	n/a	n/a	100,0%	94,5%
D.7. Healthcare-associated infections control	n/a	n/a	n/a	0%	60,0%

Source(s): Hospital de São João, EPE (2010); Centro Hospitalar de São João, EPE (2011); Centro Hospitalar de São João, EPE (2012); Administração Central do Sistema de Saúde, IP (2013); Centro Hospitalar de São João, EPE (2013); Centro Hospitalar de São João, EPE (2014); OECD (2015) (n/a – not applicable or not available)

As can be seen by Table 3.5.1.3, the percentage of first medical visit in the total of medical visits (A.1) at 26,1%, in 2014, is above to the average in all the five years under scrutiny. This means that patients are having more rapid access to consultations and, therefore, the SJHC is providing a better response to the patient needs. In the same vein, the number of patients referred to the Long-term Care Network (A.5) has increased from 430 patients (in 2011) to 784 patients (in 2014). This is an important issue to stress since has a serious impact on patients and the NHS. In fact, referring patients to these facilities implies a more efficient use of resources, reduction of costs (e.g. less costs per patient) and improving quality of care (e.g. avoiding inpatient associated complications, such as, healthcare-associated infections). Yet, these units are not sufficient to respond to the challenges of aging people and poverty, influencing the results of this indicator.

Concerning to other access indicators (i.e. A.2, A.3 and A.4), it is not possible to establish a comparison before and after the implementation of the *HVITAL's* project, since data are not available before 2012. However, the percentage of patients referred for outpatient at the adequate time (A.2) and patients treated in a timely manner (A.4) increased since 2012, which means that patients are having access to consultations and surgeries sooner than they had in the year that the *HVITAL* was implemented, contributing to efficiency and quality of care. Moreover, reducing time of waiting list for surgery (called lista de espera de inscritos para cirurgia) decreases costs associated with surgery checks (called cheques-cirurgia), which works as an alternative of the NHS to promote surgery access to patients in private sector when the maximum waiting time in public hospitals is exceeded.

At the clinical performance indicators, Table 3.5.1.3 shows that the highest value for the average length of stay is 8,06 days (in 2010) and the lowest value is 7,71 days (in 2014). Likewise, the lowest value for the percentage of day case surgery in total elective surgeries day case surgery in total elective surgeries (among surgical procedures that can be performed in day-case setting) is 49,06% (in 2010) and the highest value is 77,1% (in 2014). These results have important repercussions in terms of improving the healthcare provided and attaining a more sustainable NHS. In fact, reducing the average length of stay, as well as increasing the number of day case surgery, improve quality and efficiency, and reduce costs. Patients are less susceptible to the physical, mental and social constraints of a hospital stay and, simultaneously, they may benefit from a more rapid recovery. However, it is important to bear in mind that family and social support, as well as the patients' clinical evolution are main influences to these indicators. In the same vein,

the percentage of generic medicines prescribed has increased from 30,4% (in 2011) to 36,5% (in 2014), suggesting significant savings for NHS and patients due a direct improvement on the clinical performance of healthcare professionals whom prescribe medicines.

Regarding to other clinical performance indicators (i.e. B.2, B.3, B.4, B.5 and B.7), it is not possible to establish a comparison before and after the implementation of the *HVITAL*'s project because data are not available before 2012. Despite of this, it is important to stress that the percentage of readmissions in 30 days (B.2) and the percentage of patients with a length of stay above the maximum threshold (B.3) decreased since 2012, which means that patients are having less contact with hospital environment and all the constraints of a hospital stay.

In terms of financial performance, Table 3.5.1.3 illustrates that the SJHC has responded well to the current financial pressure, with a positive EBITDA for all available years, peaking in value in 2014 (15,9%).

In terms of regional objectives, as shown by Table 3.5.1.3, the length of time for outpatient screening at 1227 days (in 2011) has significantly reduced when compared to subsequent years, reaching 29,75% of its value in 2012 (365 days) and 0,90% in 2014 (11 days). This result suggests improvements in healthcare access for population in a timely manner. In what it concerns to the "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded, this indicator has remained roughly proportional within the period under scrutiny, with the highest value for 2013 (11,1%) and the lowest one for 2014 (9,5%). This could means that patients are having less access to thrombolytic treatment when facing an acute ischaemic stroke, which can contributes to increase the level of dependency of patients and their ability to carry out its daily activities, to increase institutionalisation and healthcare needs, and to decrease the average life expectancy. Still, it is important to stress that the thrombolytic treatment is dependent on the time that the emergency line is activated, since the treatment effectiveness is related to the time of the stroke's beginning.

Finally, it is not possible to establish a direct relation between the implementation of the *HVITAL*'s project and the results of quality's and efficiency objectives, given the existence of other possible causes for this fact. Although, looking at the available data and without any formal testing, one can see that the SJHC is being increasingly effective on the way is managing its managerial and clinical performance, and even more from 2012 onwards.

3.5.1.4 Summary of quantitative findings

The previous subchapter has presented the main quantitative findings, where secondary data were analysed for answering to the impact of the *HVITAL's* project on the managements' and clinical performance of the SJHC.

The findings suggested considerable variations on how the SJHC's manages its assets, liabilities and equity, and financially behaves. This is particularly evident in 2011 and 2013, in which major changes happened. In 2011, the SJH and *Nossa Senhora Conceição Valongo* Hospital merged into SJHC, and the introduction of a containment plan may also affected the hospital's financial performance. In 2013, new production lines were introduced within the CP, causing delays on the regular billing. Yet, it is important to stress that the SJHC has a healthy financial performance. In fact, a balanced cost of sales and an increasingly high EBITDA make it interesting from the economic point of view.

The main findings of computing financial ratios also showed a considerable volatility in the results obtained, making hard to identify a clean link between the implementation of the *HVITAL's* project and the performance of the SJHC. The liquidity and solvency levels were similar pre- and post-2012; the operational performance had improved even more from 2012 onwards; and the profitability reached the highest values in 2014, however, 2011 and 2013 were both years of great variations. Regarding to the ratio analysis, it should be considered that the new legislation created in 2012, with impact on the average number of days the SJHC takes to pay its suppliers, may have influenced one of the activity ratios (i.e. DPO).

In terms of CPs analysis, the indicators have improved after 2012, however, it is not possible to establish a direct link between the implementation of the *HVITAL's* project and the quality and efficiency results of the SJHC. In fact, more than having a BCI system to monitor all organisational processes it is important to have some cautions when analysing data, since there are other determining factors that could influence them, such as: (i) number of professionals and motivation; (ii) patients' clinical evolution; (iii) time gap between the onset of symptoms and the access of clinical care; (iv) social support; (v) new external entities requirements; (vi) economic and financial status of the country, among others.

3.5.2 Qualitative findings

The Framework approach supported the development of categories to capture the essential meaning of the data, describing and explaining the phenomenon in study, taking into account the research questions posed. The categories and the linkage between them were developed with basis on interviewees' perceptions about the impact of the *HVITAL*'s project in the SJHC. Thus, it is presented below the data obtained through interviews, for each of the categories analysed.

Reasons of implementation

Some of the interviewees had no idea about the previous organisational context to the *HVITAL's* implementation, since they did not work at the hospital on that time. Nevertheless, they made comparisons between the institutions in which they worked before coming to the SJHC, as illustrated by the following comments:

> "I was not working at this hospital, but I worked in other hospitals where the planning and control information was collected through ISs, such as the *SONHO* (the billing program, where the production activity of the hospital is documented) and other programs of the ACSS (e.g. *SICA*). Indeed, in one of the hospitals where I worked there was already a BI system, but not as the *HVITAL*. I can say this is the first time I have contact with a tool capable of collecting information from all databases of the hospital and compiles it in a structured manner." (Manager)

> "Coming to here was like water to wine, any information that we want in terms of purchases, consumptions, stocks, etc., we have in a distance of a click. It is a significantly difference compared to other sites where I worked." (Manager)

On the other hand, participants who already worked in the SJHC before the *HVITAL's* implementation remember how it was before:

> "I am from the time that I had to prepare my «*Tableau de Bord*»." (Manager)

> "I go back to the time of the «*Tableau de Bord*», where management control was more primary in the hospitals, directed related to the financial and production indicators. Today we no longer use it, given its inability to provide sufficient information to manage a hospital." (Manager)

> "The *HVITAL* is the most agile situation to get information since I work at the hospital. Before the *HVITAL* we had to extract data directly from ISs, via *SONHO's* or *RHV* applications, or ask to departments, and it was very difficult to handle the information." (Manager)

> "The stock management methodology is exactly made the same way as before the *HVITAL*'s implementation, the difference is that the *HVITAL* allows us to do things faster." (Manager)

> "The Epidemiology Centre was only founded in 2012, the same year of *HVITAL*'s implementation. Before this, there was nothing similar. Of course the Occupational Health Service and the Quality Service existed because it was mandatory, but not in an integrated manner. So, there was not a very structured and systematic approach to quality and patient safety issues, as well as no system able to provide structured information on these issues." (Healthcare professional)

After a less structured information phase, the information began to be obtained by standardised reports as part of a reporting infrastructure, called "*Medir para melhor gerir*" (meaning Measure to better manage), which was the foundation of the *HVITAL*:

> "We had an intermediate stage in 2007/2008 with a management reporting platform, where standardised maps were built from *SONHO's* program, and then exported into Excel®. Despite of information could be worked easily and faster than before, we could only analyse the variables pre-selected. There was no room or time to explore more. With the *HVITAL* was a burst of information, both in volume and diversity." (Manager)

> "With the management reporting platform was possible to obtain information in real-time, because the platform was loaded with the data entered in the ISs until the day before, but it was only possible through standardised maps. In the case of wanting to change a variable, I had to contact informatics, and the response was not immediate. Today, there is no limit." (Manager)

> "Basically the project "*Medir para melhor gerir*" was the beginning, the foundation to build the BI project, today called *HVITAL*. Before that, we performed reports that could take two or three weeks to answer a specific question. When I started working in the hospital I developed this reporting infrastructure to automate several processes. We did not have a multidimensional cube, but we were the only hospital with a «*Tableau de Bord*» fully automated and integrated with ISs. But it was only reporting, not going beyond that." (Project manager*).*

Several inefficiencies were pointed by the respondents. Poor information quality, and ineffective access of information were pointed as the main reasons to implement the *HVITAL*, as illustrated in the following citations:

> *"*We needed more information either in quantity or in quality, in a timely manner. To effectively manage a hospital is not reasonable to wait days for getting an information." (Manager)

> "To access the information I had to go directly to the services, and collect information manually, and often it did not even exist. When the information was available, it was dispersed and poorly organised, which makes impossible to perform an accurate and reliable analysis." (Manager)

> "I usually prepared monthly statistical information to give to Clinical Directors, and I can say that the time gap between the information provided and the time that occurred was approximately 15 days. The reaction time was too long, when compared with real-time capacity." (Manager)

> "The hospital needed good information to make good decisions. Information has become our vital road to take decisions on time, adequately and financially sustainable." (Manager)

> "Sometimes we looked to the information and we thought it was not right, but we had no mechanisms or means to correct it." (Manager)

> "Not having access to accurate and timely information on indicators of the CPs did not allow us to correct deviations in time." (Manager)

> "Without accurate information we were often faced with increasing expense." (Manager)

> "Without accurate and reliable information we could not managed income or costs properly. One of the goals of this hospital since it was transformed into an EPE hospital was to be economically sustainable. To accomplish that, we needed to have proper management tools." (Manager)

"Even the data that professionals have now to perform studies has nothing to do with the data that they previously had." (Manager)

"When I wanted to know more about a specific think I had to call to someone who knew this kind of information, but still I had to wait few hours for the information." (Manager)

"I needed to ask for someone to extract listings from the *SONHO*'s application and then to other person perform data relationships." (Manager)

Likewise managers, healthcare professionals considered poor information quality and ineffective access of information as the main reasons to implement the *HVITAL*, as illustrated by the quotes below:

"When you are saving lives all minutes count. The treated data makes professionals' lives easier, giving them a tool for they can better perform their jobs." (Healthcare professional)

"Probably people who were in my place had difficulty to make decisions, given poor information quality. We need proper information to know what is wrong, analyse the situation, correct deviations, and at the final end, improve the effectiveness." (Healthcare professional)

"The information about the multidrug-resistant microorganisms was obtained manually, by consultancy the laboratory IS. Regarding to antimicrobials' information, without the *HVITAL* we had no change to analyse the antibiotics consumed. To this end, the pharmaceutical services had to verbally communicate the antibiotics prescribed, and sometimes information was lost given the dimension of the hospital." (Healthcare professional)

"If physicians needed to compare the evolution of analytical parameters of blood tests they would have to write the results on paper." (Healthcare professional)

"The lack of interoperability among ISs is a monumental barrier to analyse the information needed under the Epidemiology dimensions." (Healthcare professional)

"It was very difficult to get conclusions about data, i.e. about what was right or wrong, what could be changed, optimised, reduced or increased." (Healthcare professional)

"Few years ago I had to collect data from the ISs that we had or the registration books (e.g. to count the number of implants). For example, if I wanted to know if a surgery room was occupied, or what was happening inside the room, or if the surgery was delayed, I had to call to the operating room, which was very time-consuming." (Healthcare professional)

The project manager shared the view of managers and healthcare professionals about the reasons for implementing the *HVITAL*, referring to the things that were not possible to do and those that were, albeit with significant restrictions:

"Some analyses were not possible to do due the amount of information, and hence some correlations had never been made. On things possible to do, users were very restricted. For those who decided to perform complex analyses, the report could take two or three weeks to be ready, and other users could started to feel the computer system slowing down. For others, who decided to take lists from the reporting platform and export them to Excel® sometimes made mistakes, getting different numbers of reality, and in the end you never know if the information was right or not." (Project manager)

Operationalisation

Most of interviewees were not sure about who decided to implement the *HVITAL*. The answers varied between "Board of Directors", "top management" and "*HVITAL's* project manager". Despite of this, a top manager interviewed said that it was a Board's decision, which was corroborated by the project manager, as described below:

> "The Board of Directors decided to implement the BCI, after I give the idea." (Project manager)

The BI concept was something that the project manager was familiarised since college and he believed it could bring organisational improvements, as following:

> "I specialise in medical informatics area, which is one of the Biomedical Engineering specialisations, and it has a great component of BI systems. Since college, I had a clear vision of what I wanted to implement one day and I knew perfectly, or had a great expectation, that these well-implemented engines could increase the organisational productivity." (Project manager)

After the BCI system implementation be approved, the challenge was to choose BI software's brand and the most specialised people in the BI and analytics area, with a reduced budget and a small internal team, as illustrated by the quotes below:

> "I had a vote of confidence from the Board. They asked me to implement the BI with a small budget, at most 50.0000-60.000 euros, in an early stage. I believe that this imposition resulted from the investment in other solutions in the past with no success. So the challenge was with a reduced budget, choose the best team in the area, and with our internal team try to solve the most important issues on human resources, financial, supply and logistics, and production areas. I had the luck to found the best technicians in BI area, who knew nothing about healthcare, but the best people working with Microsoft technology in the country, capable of passing me the know-how, which is something that most of suppliers do not do. This makes all the difference because if we want to modify an indicator, we would not have to spend more money contacting the supplier to change it, we do it internally. These were determinant points to the success of the *HVITAL*." (Project manager)

> "The DevScope's role was crucial. I had no budget to pay Microsoft's consultancy, so I searched for blogs in the BI area, looking for who were working in this area in Portugal. I met a Professor from Lisbon who referenced the DevScope, which is a nationally and internationally recognised consultancy agency. They brought me experts in each components, such as data extraction, multidimensional cubes, as others, saving months of potential errors because suppliers have an experience of 20 or 30 years and they know how the things should be drawn up as effectively as possible without the platform be down in a month. They brought me the assurance that knew how to work in an environment with this level of criticality, because when we start taking data we can run at risk of stopping the hospital. Basically, they had this maturity." (Project manager)

The Microsoft® was chosen for several reasons, such as licensing values and available online tutorials, as illustrated below:

> "I chose the Microsoft for two reasons. Reason number one: licensing values, far below from other market suppliers, and in some cases five times less. Reason number two, and perhaps the most important: the Microsoft has available a range of online content, training videos free of charges with thousands of hours, explaining each component of its solution, which makes all the difference to learn much faster. No other software vendors had this. This helped me to gain internal expertise to manage the solution and to be well prepared for the entire process of implementation when the supplier came here to develop the *HVITAL*." (Project manager)

At the beginning, the *HVITAL's* implementation efforts were concentrated to solve management control issues. Over time the clinical area has gained more importance, as shown below:

> "Since 2012 the BI has been evolving. Initially we only had production and consumption KPIs and, subsequently, we started to have human resources KPIs related to entrances, exits, working hours, distribution of workloads, which is critical for management since it is half of our budget. After this, the clinical indicators started to being introduced in the BI." (Manager)

> "In the first year, the available information was more directed to the management area, but I think it was the bridge to start investing on clinical area. For example, when we talk about readmission rates or average length of stay, these indicators has financial significance, but they also mean an indirect impact on efficiency and quality issues." (Healthcare Professional)

> "At the beginning, we just think about the *HVITAL's* capabilities for management control and, suddenly, we started to realise that we could use the *HVITAL* to help saving patients' lives, if clinical information could be delivered at the right time, to the right person." (Project manager)

The performance measurement is done using KPIs, which are designed by the project manager or DevScope®, as illustrated by the following citations:

> "We started with around 200-250 KPIs. Now we have 650. Initially, these indicators were proposed by the planning and control department. Many of them were usually manually exported into Excel®. So we basically tried to automate something that was previously done by hand. The first KPIs were those signed with the ARS and other that we felt to be relevant to the internal culture and management control of the hospital." (Project manager)

> "The KPIs are inserted by me or by DevScope. One of us need to do the programming and create the formula or the algorithm of the information required by the departments." (Project manager)

> "We can monitor all indicators inserted in the system of quality-benchmarking implemented by ACSS. This gives us a great advantage since we can access them in a daily basis, rather than wait six months to a year for the results of the ACSS." (Project manager)

Besides the KPIs usually be designed by the project manager or DevScope®, there are departments becoming more autonomous creating their own indicators, such as the Epidemiology Centre:

> "In a first stage we were completely dependent on the project manager or someone from the DevScope team to include KPIs in the *HVITAL*. Today is different. Recently, we started to have

interns who create clinical KPIs. Thus, after we define the indicators and write the script expression correspondent to that indicator, the intelligence team just need to implement it in the production module, and after validation they integrate it in the BI." (Healthcare professional)

Management outcomes

When the participants were asked about the impact of the *HVITAL*'s project on the management performance, they argued that real-time capacity helped them to achieve better control processes, monitor closely indicators and improve it by taking corrective action in a timely manner, promote professional accountability adjust resources to the needs, and perform more comprehensive analyses, as illustrated by the following citations:

"In financial terms the *HVITAL* have been helping to know where we are spending, saving and investing. The *HVITAL* provides helpful information letting us know what we are financially doing, and compare if we are aligned with the budget or if there are deviations that need to be corrected. In the case of deviations, we have plenty of time to take corrective action since we have information in a timely manner, reliable and user-friendly." (Manager)

"In the SJHC we are financially stable because we have a BI that allow us to understand the effects and the impact of acts. People are now confronted with the practical result of their acts." (Manager)

"In terms of operational area (clinical and non-clinical), the *HVITAL* has been very useful, influencing positively many processes and procedures, such as controlling the operating rooms and stocks, both excellent examples of successful intervention. As we have more accurate information it is possible to efficiently manage resources, rules and procedures, because it is different having information from not have it." (Manager)

"The *HVITAL* is absolutely critical for improve the performance indicators signed with the ARS, since we can monitoring them closely with the *HVITAL*. The answer is clearly positive in the quality and efficiency results. For example, the average length of stay it was a goal that we could relatively improve with the *HVITAL*. But the lack of more social support, or the lack of it, is a barrier to improve more." (Manager).

"We are having excellent budget execution rates, both in terms of revenue and costs, and excellent CPs execution rates. We can now anticipate the results and correct deviations, so when we are almost getting to the end of the year I am already prepared for the numbers." (Manager)

"To the Board of Directors is now easier to know if processes are ineffective given the lack of resources or to the poor organisation." (Manager)

"Today, we are able to respond to the Board requests quickly. Our ability to take decisions, evaluate situations and decide is infinitely greater. And even for the Board they have become used to request answers of questions that was not possible to be responded in the past." (Manager)

"Today, there is no limit. I can do a different map every single day. I can respond in one to three hours to any request, depending on the volume and specificity of information." (Manager)

"The *HVITAL* provides useful information for management. I can access to a great amount of information easily and quickly. I also gained the ability to control closely all processes, in real-time, and take corrective measures whenever is needed." (Manager)

"We can perform analysis quicker, and alert the Clinical Directors about deviations from the objectives defined sooner than before." (Manager)

> "From the moment we had the possibility of monitor indicators in more detail and regularly, realise what we were doing, and detect deviations and understanding where they come from, our intervention capacity has become greater. Our performance levels are related to the *HVITAL* because in some indicators we knew we were bad, but we had no ways to perform an accurate and detail analysis in order to adapt corrective strategies. This informational capacity improvement has a direct impact on cost-saving, efficiency, quality of care, among others." (Manager)

> "I think the *HVITAL* had impact at all performance levels: financial, economic, efficiency, quality. The main asset of the *HVITAL* is the information that it brings, which was "closed" for long in services and in the most of cases no one could access it. Or we asked to the Clinical Director of that service or we could not get it. The *HVITAL* help us to change the informational culture, where all information is available for everybody who needs. This certainly changes the culture of an organisation. And this is what make possible to achieve the objectives, because the processes can be changed quicker." (Project manager)

> "It is possible to adopt immediately correct measures when we have deviations from the objectives defined. For example, we already closed operating rooms, because looking at the number the utilisation were not being efficient. The same happens for the number of beds, prescriptions of medicines, among other. Basically, this is the great asset of having an intelligence solution like this one: show the problems and help decision makers to act immediately to not let the process carry on long time out of normality." (Project manager)

Regarding to the internal audit, the *HVITAL* was also determinant to achieve positive outcomes, as described by the following quotes:

> "Given our dimension, the specific audit objectives for each action, the possibility of extending samples, having a global picture is certainly an asset. It is a great satisfaction. Moreover, I do not have to recur routinely to intermediaries and this facilitates my work, not having to be dependent on others anymore or to request help to informatics or human resources." (Manager)

> "We can do easily more comprehensive analyses. For example, in the supply area, I can go to the *HVITAL* and evaluate a number of variables, such as the type of contract, and check how many direct adjustments, public procurements, and amounts are involved, etc. With the *HVITAL* I can easily adjust the variables that I want with my activity to perform analysis in a timely manner. I can also easily check the evolution of purchases, stocks, consumption. The HVITAL give me this information and I can still go to detail by the cost centres. It is a matter of detail." (Manager)

Concerning to inventory management area, the *HVITAL* was also determinant to achieve positive outcomes, as described by the quotes below:

> "All information that we get are not obtained through algorithms that take days or weeks to run, we have information in real-time. This allow me to do things faster, such as rupture analyses, defining quickly the priorities for my day, which suppliers do I have to contact, what materials are at risk of running out in the next day." (Manager)

> "In addition to making things faster, the stock management became more efficient and we do not need to have a lot of material because we know when it will be needed it and when we have to order. Basically it is the information working on. When the time is reduced, the efficiency increases. We do not stop doing things, we just produce more in less time." (Manager)

> "I would say that the time between the request and acquisition of goods passed from one day to half a day. Seeming that not, it is still significant." (Manager)

Concerning to the structural healthcare reforms, such as the merger of the SJHC with the *Nossa Senhora Conceição Valongo* Hospital, the *HVITAL's* role was to monitor both hospitals by integrating all ISs:

> "To monitor the two structures at the same time, something that would not be certainly easy if the *HVITAL* did not exist, we use the *HVITAL* to analyse information in the same "machine", instead of using two different "machines" and two separate *SONHO's* programs. The *HVITAL* helped to gather information from both hospitals in an integrated and structured way." (Manager)

According to the interviewees, the Board of Directors also used the *HVITAL* as a competitive advantage tool to face the financial crisis, such as to maintain the same levels of performance, provide additional and accurate information to the Public Health Entities, and to negotiate with the pharmaceutical industry:

> "The results being achieved by the hospital are influenced by the *HVITAL*, especially in this period of time influenced by strong financial budget restrictions. Even so, the hospital has maintaining the same levels of quality, and economic and financial performance." (Manager)

> "The hospital does not have overdue debt and has a positive EBITDA (…). Despite of the crisis implications, the *HVITAL* helped to maintain the same level of performance." (Manager)

> "The *HVITAL* had some influence in the available information and the ability to make decisions quickly. There were several constraints in the years of 2011, 2012 and 2013, such as reducing of investing and the loss of recruitment capacity. We had to do a very thorough monitoring of human resources (e.g. spending on overtime) and provide a level of very detailed information, higher than normal, to external entities, such as the Ministry of Health, ACSS and ARS. The *HVITAL* helped to achieve high efficient and quality performance levels with the available human resources and quickly respond to the Board of Directors for they make effective decisions in a short time and still inform the external entities about what they asked." (Manager)

> "To answer to the internal and external information needs, all macro analyses would be impossible to perform without the *HVITAL*, given the volume, detail and time required." (Manager)

> "When a Board of Directors are negotiating with a pharmaceutical, how much is it worth to have timely information? Nowadays, even the suppliers realise that the hospital knows better about the service they provide than themselves. This gives us a great negotiating power." (Project manager)

The *HVITAL* is also being an important asset to automate projects, as illustrated by the quote below:

> "In the management area we are working in the integration of two applications with the *HVITAL*, a Balanced Scorecard and a costing system. Regarding to the Balanced Scorecard the aim is to integrate all indicators with the *HVITAL*. At the moment, we need to manually collect some of the indicators non-integrated with the *HVITAL* in the Balanced Scorecard application to do our monthly performance analysis. Regarding to the costing system, our goal is automatize information at a very opportune time, by the 15th day of the following month to be exactly. This could be accomplished by integrating the costing system with the *HVITAL*, helping us to determine accounting information in detail, for example, the unit costs per patient of outpatient visits, emergency episode, hospital stay." (Manager)

After addressing the relation between the *HVITAL* with the management outcomes, professionals end this topic making a positive balance of the BCI system, as illustrated by the citations below:

> "Globally the balance is very positive. With the *HVITAL* we have been generating positive results. The *HVITAL* is a source of information that give us the ability to improve our performance levels, to make investments, reduce the debt to suppliers, among others. Notice that even in an economic and financial recession we never stopped of increasing our production." (Manager).

> "The balance is excellent. I am a fan of the *HVITAL*. I feel privileged to be working in an institution where there is a BI system like this one." (Manager)

> "The *HVITAL* is vital for managers and clinicians. Everything we do reflects on patient care: or because we analyse better the waiting time list and we realise that are patients forgotten, or the consumption of something is quite different of expected, or we can buy other product less costly. These situations are from easy resolution because we have the *HVITAL*, and we can test variables accurately and quickly. This ability to make decisions with basis on reliable information is critical to improve quality of care. Today we would not know live without the *HVITAL*." (Manager)

> "In my day-to-day every time I need answer the phone for someone who is asking listings of what they spent this year or prices of materials that are spending, among other, I can give this information almost readily. Usually 10 minutes later I am sending this type of information. Obviously, without the *HVITAL* we would regress around 10 years." (Manager)

> "The balance is very positive. From a strategic point of view, managers became increasingly demanding after the *HVITAL's* implementation. Nowadays, managers do not admit wait more than one or two hours to have information, while before they sometimes waited a week for the same information." (Project manager)

Clinical outcomes

When the participants were asked about the *HVITAL's* impact on the clinical performance, they argued that real-time capacity helped them to prioritise interventions according to the patient needs, accompanying the patient health status evolution, identifying bad practices, correcting deviations in a timely manner, and improving production, quality and efficiency indicators, as illustrated by the following citations:

> "Physicians are now able to check the patient's progress and trends. Moreover, every time a patient's health status changes the *HVITAL* sends automatically a message to the physicians' phone. This is a revolutionary thing that can save lives. If we think that often is a matter of time, it is phenomenal for physicians be able to prioritise the care according to patients' risk." (Manager)

> "The *HVITAL* helps to understand the linkage between practices and outcomes, and in the case of we identify a bad practice we can implement actions to correct it." (Manager)

> "To the on call physician, with 100 patients to take care, it would be impossible to prioritise which patients should be seen first. With the *HVITAL* it started to be easier, since the physician receive alerts when patients are deteriorating." (Healthcare professional)

> "With the *HVITAL* we can select certain parameters and it gives us an overview of what is happening with a patient." (Healthcare professional)

"Today we know, for example, in our elderly population what is the percentage of malnourished inpatients." (Healthcare professional)

"With the *HVITAL* we can perform a number of analyses, combining different clinical indicators. For example, we did an analysis where we conclude that the patients with more pressure ulcers were those diagnosed with pneumonia." (Healthcare professional)

"For someone who is managing a service with two floors, with 70 inpatients, several operating rooms running at the same time, an Accident and Emergency department with the doors open, outpatients running, I can follow everything from the distance of a click. Without the HVITAL it was impossible to have this type of control. For example, I usually use the *HVITAL* to compare the actual average length of stay with the same period of the previous year. In the case of deviations, I immediately implement action to correct it, as far as possible." (Healthcare professional)

"We feel that the *HVITAL* is having impact in operational terms." (*HVITAL's* project manager)

Regarding to quality and patient safety areas, the outcomes are the following:

"We had the advantage of finding a "partner", which provides the best conditions to get access to information, with a user-friendly interface." (Healthcare professional).

"If we think about the frameworks and methodologies for assessing and improving the quality and patient safety area, what are they based? In evaluating how we are, what we are doing and comparing it with the recommended international standards. Having a BI system helping us to monitoring all steps, the impact is huge." (Healthcare professional)

"To perform epidemiological analyses, the *HVITAL* is absolutely critical, since this area relies heavily on quantitative analyses of occurrences, which are used to know the causes and the magnitude of problems. Without the privileged access to *HVITAL's* information it would be impossible to perform such detailed analyses. For example, recently we tried to understand the magnitude and the causes of admissions less than 24 hours, using the information provided by the *HVITAL*. We found the services where this were frequently happening and the most common situations of this type of admissions (e.g., one-day surgeries, patients who needed to be seen by a certain specialty non-available in the referral hospital, avoidable admissions by patients that did not stop anticoagulation before an elective surgery, among others). Thankful to *HVITAL*, we created some patterns of causes of admissions less than 24 hours and made inferences about what if they were justifiable or not, without need to check case by case." (Healthcare professional)

Concerning to healthcare-associated infections area, the *HVITAL* was also determinant to achieve positive outcomes, as described by the following quotes:

"The healthcare-associated infections is an area that has been targeted in the regional indicators, and I can say that is adequately monitored since two years after the *HVITAL's* implementation." (Manager)

"The *HVITAL* contributes to monitor the monthly indicators, allowing us to know what we are doing (the outcomes) and take action to correct deviations." (Healthcare professional)

"The *HVITAL* is the only way to have an overview of all inpatients, in real-time. For example, the antimicrobial assistance program is completely dependent on information provided by the *HVITAL*. Without this solution we cannot do what we actually do." (Healthcare professional)

"The *HVITAL* is very useful on saving days of hospitalisation caused by infections, because we take decisions faster." (Healthcare professional)

"We have algorithms introduced in the *HVITAL's* platform and the system tracks them automatically, giving us an overview of what is happening in the form of daily reports by patient or by microorganism. The system also alert us whenever a patient has a multidrug-resistant infection." (Healthcare professional)

"We can access the history of inpatients' antibiotic consumption by service, and the name of the prescriber. With this information we can follow if the antibiotic is justifiable, and in some cases collaborate with the prescriber to optimise or change the prescription in situations such as broad spectrum antibiotics prescribed or antibiotics prescribed for too long. We gained detection ability, something that we do not have prior to the *HVITAL's* implementation." (Healthcare professional)

"From the clinicians' perspectives there are clear clinical outcomes provided by the *HVITAL*. For example, once the databases are statics they do not need constantly open the laboratory IS to check the results of a culture performed yesterday. In the case of being a multidrug-resistant microorganism, the *HVITAL* will send an alert to the patient's clinical file. The same for antibiotics that could be quickly adjust in terms of microbiology data. This reduce the time spending by Professionals, improving efficiency." (Healthcare professional)

Some interviewees argued about the importance of the *HVITAL* regarding to the development of scientific researches and projects, as illustrated by the quotes below:

"We can easily access accurate and reliable information to develop scientific researches, based on our population features. It is much easier to perform such studies because we have the data concentrated in the *HVITAL*." (Healthcare professional)

"Every day I had Physicians saying that they were observing 50/60 children in a day, more on weekdays and less on weekend. If we think that 60 children require 120 consultations, I thought there was a need to create the subspecialty of Paediatric Orthopaedics in the Accident and Emergency room. To accomplish that, the *HVITAL* helped me to understand what was happening, giving me the real numbers. After this, I could put specialists between the 12h to 24h, and why? For higher returns. And how did I know? The *HVITAL* helped me to know the flow of children throughout the day, and that time was the period in which 80% of children come to the Accident and Emergency room. The results were better cost control, efficiency and quality of care, since we could give a proper answer to children in the period of time they most needed. Good information is valuable in these type of things." (Healthcare professional)

"There is a European project that the hospital is running under the Nutrition area to evaluate the nutritional status of all elderly inpatients. In the first days I was taking an average of more than three hours to assess inpatients of six services. After I requested help to the project manager, I started to have reports of patients at higher risk of malnourishing in 30 minutes, assessing a population of 980 patients." (Healthcare professional)

"We participated in a working group, which was led by immuno-transfusion service, aiming to develop a clinical protocol for the prevention of pulmonary thromboembolism. The strategy was to create a tool for assessing the risk level of developing pulmonary thromboembolism, suggesting automatically the prophylactic therapy according to the risk level, although the Physician has to validate the prescription first. Our role was to evaluate the compliance of the project with the clinical protocol, define KPIs that did not exist in the *HVITAL* (e.g. incidence rate of pulmonary thromboembolism), and evaluate the impact of the project." (Healthcare professional)

"The idea was to create a project anchored in the *HVITAL*, measuring the physiological state of patients. Several professionals were involved in this project, and it was first implemented in two wards (surgery and internal medicine). It serves as an early warning score, track and trigger system to monitor the health status of patients, warning about those who are unstable or at higher risk of deteriorating in short-term. Besides vital signs, we also included signs of renal function deteriorating, inflammatory systemic signs, and hydroelectrolytic changes. We defined ranges and cut-offs for all parameters (normal and abnormal levels of each parameter associated to the clinical

significance), and patients at immediate risk the system marked them with red colour. The *HVITAL* offers a user-friendly interface, assisting physicians to have an integrated overview of parameters' evolution. The difference is that we can have an overview of the physiological state of patients in an unique piece, a dashboard, understanding patterns that otherwise could only be made by making a historical analysis of nursing records, blood tests results and image results. In the meantime, we also started testing the predictive ability of the *HVITAL* about the patients at higher risk be transferred to intensive care units or die in 24 hourly, 72 hourly or in the next week. This information is displayed in the *HVITAL* by descending order of severity based on the risk score, which is for example very useful for the emergency internal physicians or residents who are responsible for many patients who do not know, realising who is at higher or lower risk prioritising their intervention without being called." (Healthcare professional)

"In 2014 we implemented a program of antimicrobial prescription assistance. This required adding algorithms in the *HVITAL* about what we wanted to include in reports. This project helped to better control the existent microorganisms and the antimicrobials consumed. It is not our purpose to take out autonomy from other professionals, but assisting them to enhance the patients' treatment. It is a different way of intervene within a hospital." (Healthcare professional)

After addressing the relation between the *HVITAL* with the clinical outcomes, professionals end this topic making a positive balance of the BCI system, as illustrated by the citations below:

"The balance is very positive. In fact, we improved, and what we thought it was impossible to do it becomes possible." (Healthcare professional)

"The balance is positive. The *HVITAL* helped us to improve some things, allowing us to know what we are doing, and understand why some unwanted things were happening." (Healthcare processional)

"The information helped to improve the service. If you check the last three years, we have been steadily improving, the number of outpatient consultations, the number of patients treated, the number of surgeries performed. This is possible because I have adequate information." (Healthcare professional)

"The balance is very positive. We assist now healthcare professionals changing their decisions with basis on information gathered in real-time." (Project manager)

Organisational culture

Professionals from all functional areas believe in the professional pride and hospital's brand image as other impacts to the performance levels achieved in the last years by the SJHC, as illustrated by the extracts of interviews below:

"The results are obtained by the professionals working in the hospital." (Manager)

"People walk on top of the things and correct what can be corrected, they do not simply accommodate. When there is good will, everything is possible. Here in the SJHC, professionals like to be challenged, and they respond positively to challenges." (Manager)

"People's work. The big step here was the combination of people and intelligent tools. But, the dedication of people to train colleagues, requiring several working hours, has been a determinant effort to achieve positive results." (Healthcare professional)

"People. Culture of "loving the shirt", always desiring to do better." (Project manager)

"We have a strong leadership that invest greatly improving the quality." (Manager)

"The results do not come only from the *HVITAL*, it is a whole philosophy of management that is settled here. I think we have a strong leadership that invests greatly in improving the quality, and this has repercussions on the hospital performance." (Manager)

"I think it is the vision of the institution. We have a constant and regular concern with it." (Manager)

"The Board of Directors attributes great importance in development and innovation investments." (Healthcare professional)

"The strength and the support of the Board of Directors, and the love by the *São João*'s brand, which is the most notorious health brand among the Portuguese hospitals." (Project manager)

Modifications

The participants' agreed about the fact that there is a lot of work to do in order to improve the *HVITAL's* project. The interviewees argued that the *HVITAL* has considerable changed since its implementation in 2012, but there are still important modifications to do in the future. One of these changes is related to the data integration of some applications or parameters (e.g. Balanced Scorecard, biometric registration, allergies and adverse reactions registration) with the *HVITAL*. Furthermore, some of the participants explained that after the investment in management control indicators it is time to invest in clinical area, such as illustrated by the quotes below:

"I would like to have more clinical control. The management control we do have, and we will not progress much more. At management level, all the parameters required by the ACSS in terms of quality are already measured by the *HVITAL*. We need to evolve more in the clinical area." (Healthcare professional)

"The monitoring of the response times of collaborative requests by Cardiology, Imunohaemotherapy, Medical imaging, among others, is something that also could be very useful since it interferes with the waiting times for surgery." (Healthcare professional)

"Today, we realise that in the clinical area is where we can make the difference. In relation to the management performance, there is nothing else that we can make to have a big impact, just few improvements. At the clinical performance, where healthcare professionals usually lose hours trying to relate risk factors for a given patient until they can make a decision, there is an endless path to do." (Project manager)

Some of the respondents went further, claiming the need of investing in more KPIs specifically related to the Nursing area:

> "We gave the first steps on the production indicators, but we have much more to do. The model is very good but we need to create more Nursing indicators. If we cannot prove our performance with basis on numbers, we cannot prove our value." (Healthcare professional)

Besides the need of building more indicators, the Professionals' inclusion was pointed as one of the most challenging modification to do, either in the way they are getting access to information or interpreting it, as described by the following quotes:

> "All professionals quickly accessing the information provided by the *HVITAL* is our great challenge. The problem is that in most cases people do not know how to access, therefore, we need to train them. We have already given training to professionals on how to access to information through Excel®, but some of them do not use the Excel®, such as Nursing. In such case, we created a specific portal for Nursing. Still, they have to know the gate address. This is an issue that we certainly need to improve." (Project manager)

> "Sharing information and reporting mechanisms are the biggest challenges of this type of projects. There is an on-going strategy to install wireless within the hospital for people start to access information by mobile devices. Another thing we want to do is sending all indicators by email to ensure that information gets there." (Project manager)

> "I do not know if Nurses are requesting daily reports with some critical analysis about the patients, but if I was a Practice Nurse in a context of a Medicine ward, taking care of 10 patients, I certainly would, because I see *HVITAL* as a very useful tool for me. However, my perception is that Nurses are not accessing to the information provided by the *HVITAL* because they need to enter to a Portal that is still a little slow, and the shift time is difficult to document in the *SClinico* and take reports from the Portal too. I think that the Nurses could become more interested if they also have access to message alerts." (Healthcare professional)

> "There is a lot to do. When people watch presentations about these intelligence tools they think is awesome, but if they do not understand the real impact of these tools in their daily work we will not achieve the expected outcomes. It is necessary to train people, and make them aware about the importance of being cautious when analysing information." (Healthcare professional)

> "It is important that people use this tool for what they need to know, but take some caution to use it properly, to interpret the information in an adequate manner, to know exactly what the information means. I am very conservative in this issues. I am afraid that people misunderstand the information and then introduce more risk than benefit." (Healthcare professional)

> "There is a lack of skilled Nurses to manage, analyse and interpret information. This is a rooted culture in Nursing that has to change. It is not enough to have an intelligence system that provides useful information, we must know how to use it." (Healthcare professional)

Other reported modification concerns to the contribution of the *HVITAL* in the production of scientific research, since the *HVITAL* help to collect accurate, reliable and timely information, as illustrated by the citations below:

> "Since we created the Epidemiology department, one of the things we are doing with the Medical students is motivating them to use information collected from the *HVITAL* for their dissertations and thesis." (Project manager)

> "It is something that is still beginning, because people are still unaware of the *HVITAL's* potential for clinical research." (Project manager)

Although participants considered that there is room for improvement, since the *HVITAL* is a project in constant development, one of the interviewees explained that in the infection control area it is important to bear in mind the reality of a hospital with a dimension as the SJHC:

> "There is a lot to do, but we have to keep in mind that the SJHC is a highly differentiated hospital, with a very high pressure at the infection control levels and antibiotic consumption. We have a population of patients with a high exposure to risk factors in healthcare services, and submitted to medicines or interventions that increase the infection risk. Indeed, our antibiotics' prescriptions rate is not much superior (50%) to the case-mix of OECD data (46-48%), but we need to be conscious that the pressure is high." (Healthcare professional)

Development of new analytical tools

The interviewees' opinions about the need to further enhance the *HVITAL's* capabilities through new analytical tools seems to be unanimous. Data mining is pointed as one of the most promising analytical tools in the *HVITAL's* future, especially in relation to its impact on clinical outcomes, as described below:

> "On artificial intelligent issues. There are no limits at management level. But at the clinical level, make predictive models will be phenomenal. The future is unlimited on this type of things." (Manager)

> "At treatment level, the *HVITAL* could give more answers predicting, for example, a better adherence to certain treatments, given the analytical parameters, age, sex, among other factors, as well as creating patterns. For example, if the physician decide to discharge a patient and the *HVITAL* send a message saying that discharging a patient under such conditions could contribute for a readmission in 3 days, well, I think that it is an area that could be very useful." (Manager)

> "There are many areas of opportunity. In short-time we will have data saying to us that for a given infection, the antibiotic x is effective in x days of administration, reducing the length of time of antibiotic administration, costs and hospital stays' constraints" (Healthcare professional)

> "The determination of risk factors could contribute to have greater ability to predict the patients at higher risk and, eventually, intervene and use preventive measures before the onset of multidrug-resistant microorganisms. This can only be achieved with basis on a tool such as the *HVITAL*. The future passes through crossing the information provided by the *HVITAL*, infection markers, microbiology, microbiological past history of the patient." (Healthcare professional)

> "The features of each patient are so different that normalise what can be normalised will be very interesting to improve practices. For example, understand the relation between the average length of stay of a cannula and the increase of inflammatory parameters." (Healthcare professional)

> "I need a bigger team to start working in an area that is very important that is artificial intelligence. My ambition is that this solution can increasingly help stratifying the risk of each patient, from the moment the patient comes to the hospital till discharge, measuring accurately and reliably, for example, what is the likelihood of the patient get a multidrug-resistant infection, a thromboembolism or responding better to antibiotic A than the antibiotic B, and ultimately give this information to clinicians in real-time. I think the day the clinicians have access to this type of information and get it in a second, we will be able to compete with the best American clinics." (Project manager)

3.5.2.1 Summary of qualitative findings

The previous subchapter has presented the main qualitative findings, where primary data were analysed for answering to the reasons of why the *HVITAL's* project was implemented, details about how it was put into practice, and its impact on the managements' and clinical performance of the SJHC.

The findings suggested that whether professionals working at the SJHC at the time of the *HVITAL's* implementation, whether those who did not, argued that obtaining good health information in a distance of a click is something that they were not used to have. Some of the respondents shared how they controlled organisational processes before the implementation of the *HVITAL*, through *Tableau de Bords* and/or standardised reports from a reporting platform, remembering them as ineffective from the point of view of providing insufficient information to manage a hospital.

Poor information quality, and ineffective access of information were pointed as the main reasons to implement the *HVITAL*, more particularly: (i) data were not of sufficient quality or quantity, or available in a time manner, with a lag of several days or weeks; (ii) dependency on others to gain access to information; (iii) data were obtained manually directly from the ISs or by standardised reports from a reporting platform manually exported into Excel®, resulting in potential data placement errors and a time-consuming process; (iv) lack of interoperability among ISs, compromising data analyses; (v) some analyses were not possible to perform without a system as the *HVITAL*.

Providing access to all professionals with accurate, reliable and timely information to improve effective decision making was the main goal of the *HVITAL's* implementation. After the Board of Directors approved the implementation of the BCI system, the project manager implemented his idea with a limited budget and a small internal team to solve management control issues. Further, the project manager looked for the most specialised people in the BI and analytics area to transmit the know-how at the early stages of the project implementation, which was considered determinant for the success of the *HVITAL's* project.

For managers, the management outcomes are clear to all: excellent budget execution rates, both in terms of revenue and costs, and excellent CPs execution rates. The performance results are not abstract anymore and the processes are done faster than before, because they have good control and take decisions more quickly than before, with basis on numbers. Managers gained the real-time capacity to know where the money is spent, saved and invested, constantly aligned with the budget, contributing to the financial

stability of the hospital. The *HVITAL* also provides the ability to monitor closely indicators and improve it by taking corrective action in a timely manner, promote professional accountability, adjust resources to the needs (e.g. close operating rooms, decrease the number of beds, anticipate stock ruptures), and perform more comprehensive analyses. Managers also referred to the role of the *HVITAL* for obtaining information in an integrated manner when the SJH and *Nossa Senhora Conceição Valongo* Hospital were merged, as well as to face the austerity requirements of the AP. Finally, the interviewees considered that while management processes are now almost well performed, with exception for fully automating the Balanced Scorecard and the costing system, there is a long path to do in the clinical area.

The *HVITAL* has been positively contributing to clinical performance, particularly on areas such as quality and patient safety, and infection control. According to the participants, since the *HVITAL* was implemented it is possible to have an overview of patients' health status, check parameters tendencies and compare the progresses regularly, prioritise patients' needs with basis on deterioration risk levels, identify bad practices quickly, perform analyses with several clinical indicators, and get more involved in projects that would be impossible to work with no integration of the *HVITAL*.

Apart from the impact of the HVITAL on the managements' and clinical performance levels, the main findings suggested the organisational culture as other improvement factor of the SJHC, more particularly the professional motivation and the hospital's brand image. The belonging feeling, the motivation of trying to do better and working for something greater, the leadership, and the SJHC's brand are seen as strong contributions to the hospital success.

The participants' opinions were unanimous about the room for possible modifications of the *HVITAL*, as well as its potential outcomes. While management performance needs were well responded till the moment with few improvements to achieve in the long-run, the interviewees considered the importance of creating more clinical KPIs, particularly in nursing area. Other modifications were concerned to people start to take advantage of the *HVITAL* to produce more scientific researches, and invest in training people to better understand the real impact of the *HVITAL* in their daily work. Furthermore, the future of the *HVITAL* seems to pass through the development of new analytical tools, such as data mining.

Chapter 4. DISCUSSION

The quantitative findings of this study showed that it is hard to identify a clean link between the implementation of the *HVITAL*'s project and the performance of the SJHC. In fact, beyond the existing limitations of measuring benefits or outcomes in a non-profit organisation as claimed by Anthony, Dearden and Bedford (1984), several structural changes occurred in the period of time under scrutiny in the hospital, in response to the global financial and economic crisis and to the hospital reforms undertaken in the last decades (Barros, Machado and Simões, 2011; Simões, 2013; Sakellarides, Castelo-Branco, Barbosa and Azevedo, 2014; OECD, 2015). Yet, there was some evidence suggesting that the operating performance of the SJHC improved both in quality and efficiency after 2012. This is corroborated by the qualitative findings, where it was clearly suggested that the *HVITAL* has had a positive and significant impact on the managements' and clinical performance levels.

Since the *HVITAL* was implemented in the SJHC to overcome informational inefficiencies, managers considered that it has improved the decision-making process, which is consistent with the findings of some studies approached (Horvath, Winfield, Evans, Slopek, Shang and Ferranti, 2011; AlHazme, Rana and De Lucca, 2014). In the same vein, healthcare professionals have been started to realise the potential of the *HVITAL* to improve clinical care, for example, by getting more involved in projects. The evidence suggest (Gonçalves, Santos and Cruz, 2012) that BI systems can be very useful to analyse big clinical data and perform predictive and modelling analyses. According to the findings, the SJHC's professionals are already familiar with big data analyses, however the development of predictive and modelling analysis is something that the intelligence department have interest to exploit if more human resources were recruited.

Other interesting modification to improve clinical care is concerned to the production of more scientific researches. However, the lack of relevant skills and knowledge to exploit data and interpret it in an adequately manner it is something that should be well addressed by the hospital, since it can be an obstacle to effective decision making, as mentioned by some interviewees and supported by Foshay and Kuziemsky (2013).

Apart from the impact of the *HVITAL* on the hospital performance, both at the managerial and clinical levels, other related organisational culture factors of performance improvement were pointed by the participants. These findings meet the idea that despite of the *HVITAL* has been supporting the outcomes achieved by the hospital after its

implementation, the organisational culture has also had. In this sense, one conclude that the combination of the *HVITAL* with a good management structure and motivated professionals may be the SJHC's success key.

Chapter 5. CONCLUSIONS

The focus on good health information for improving performance measurement has never been greater. Healthcare organisations have recently started to invest in BI systems to make healthcare delivery more consistent and less costly. The SJHC is one of the Portuguese hospitals that invested in a BCI project in 2012, called *HVITAL*, to collect, store and analyse a massive amount of data in real-time, and transform it into useful information to support decision making. Thus, this dissertation presented an exploratory case study aiming to evaluate the impact of implementing the *HVITAL's* project in the SJHC, Oporto, between the period of 2010 to 2014.

The methodology used in the case was a mixed method research. From the quantitative perspective, the financial statement and contract program analyses suggested that it is hard to identify a clean link between the implementation of the *HVITAL's* project and the performance of the SJHC. From the qualitative point of view, a thematic analysis was performed showing that the *HVITAL* was initially implemented to solve management control issues and it has had a positive and significant impact on the managements' and clinical performance levels. This project has been acting as a useful decision support tool, providing accurate, reliable, timely and accessible information to all professionals improve decision making, especially when combined with a good management structure and motivated professionals.

5.1. Contributions

The main contribution of this study to the existing literature is the insight provided by this BCI solution in one of the best Portuguese hospitals. Although the findings are based on a single hospital, there are cases in management field that can only be understood in this way, going to a site and learning the more we can about it. In this sense, the present study contributed to the further understanding of the role of the BI systems in healthcare organisational decision-making, providing new insights on how and why these intelligence systems are being implemented in healthcare organisations, as well as its impact on management and clinical performance levels. This could be an important issue for future empirical studies, broadcasting the importance of this topic among the scientific healthcare community. Furthermore, it could also be a starting point for healthcare managers decide to implement BI systems in national and international hospitals, in order to achieve more economic and financial sustainability, and higher levels of efficiency and quality of care.

5.2. Limitations

The dissertation findings have a number of limitations. One of them was the case study design. A holistic and single case study offers a better insight about the phenomenon in study as a whole, however, it also provides a poor basis for generalising.

Other limitation is concerned to the constraints of time to perform a mixed method research. Despite of the scope of the study was to obtain a comprehensive understanding of the impact of the *HVITAL's* project in the SJHC through quantitative and qualitative methodologies, a mixed method research is very time consuming. This limited the time and the depth required for each methodologic approach, especially the qualitative one.

The selection of the participants for interviewing is pointed as another barrier. To ensure the sample of participants for interviewing was adequately robust and diverse, the intention was to recruit participants according to their daily involvement with the *HVITAL's* project and their functional areas (management and clinical). In such case, the participants were selected in collaboration with the *HVITAL*'s project manager to be interviewed in 16 and 17 December of 2015, which limited the availability of other possible participants who could not be available in the chosen dates. Also, the selection of dates were dependent on the availability of the project manager and researcher.

The distance of the hospital and the residence of the researcher was also identified as a limitation, especially to the interviews' arrangements, being an expensive and time-consuming process.

5.3. Future research

This dissertation addressed and answered the research questions posed. However, this study has raised even more questions. The findings of this dissertation point to a number of directions that could be pursued in the future researches.

Further research might be done aiming to capture the effectiveness of the recent projects implemented in integration with the *HVITAL*, concerning to patients risk stratification classification, antimicrobial assistance prescription program, balanced scorecard and costing system. It would also be interesting to study the impact of the *HVITAL's* project in specific services, such as operating room, and accident and emergency (i.e. what has changed since the *HVITAL* was implemented).

In what it concerns to prediction analytics, potential studies could be related to the segmentation of SJHC's population to understand the health patterns of community, quantifying their risk factors to identify the individuals who would benefit from proactive

care, justifying the implementation of new specific projects. In this case the predictive modelling analysis could also be used in order to evaluate the cost-effectiveness of such projects. Other predictive models could be performed about the patients who likely benefit or not from surgery or other clinical interventions, patients at higher risk of complications, and disease patterns and its outbreaks and transmission.

Other suggesting future research avenues are concerned to the evaluation of the Portuguese institutions' needs of implementing BI systems, as a way of identify the main causes of sub-optimal decision-making process, and the relationship between the information provided by the BI systems and the outcomes achieved by healthcare organisations. For those which already have BI systems, it would be interesting to select comparable multiple real-life cases (i.e. health units with similar dimensions) to examine in depth what has been the impact of the BI systems in their performance. Correlating individual data elements while incorporating trending benchmarking between organisations, it would help to determine how well they are progressing the goals. Some organisations can be in the early-stages of BI development and some further along the learning curve, but this type of analysis helps organisations to improve processes, learning from who has the best performance.

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Appendix 1 – Interview guide

Dimension(s)	Questions	Prompts/Probes
- Planning and control (A) - Intelligence ISs (B) - Clinical care - Quality and patient safety - Healthcare-associated infections - Inventory management - Internal audit	1. How did you get information about your functional area before *HVITAL's* project implementation?	- The management control was more focused on financial or process levels? (A) (B) - Was information easily accessible? In real-time? - What were the main problems or inefficiencies?
- Planning and control - Intelligence ISs (C) - Clinical car - Quality and patient safety - Healthcare-associated infections - Inventory management - Internal audit	2. What were the main reasons to invest in a Business and Clinical Intelligence project for the SJHC?	- To reduce costs? - To increase efficiency? - To improve quality? - The idea of implementing a BI system was made by whom? - Were you already familiar with the BI concept when you started working at the SJHC? (C)
- Planning and control - Intelligence ISs - Clinical care - Quality and patient safety - Healthcare-associated infections - Inventory management	3. What has changed in your daily work since the *HVITAL's* implementation?	- Is it useful? How? - Is it contribute for a better decision making and better outcomes to patients? - What is your level of perception about the professionals' acceptance in relation to the *HVITAL*?

Dimension(s)	Questions	Prompts/Probes
- Internal audit		
- Planning and control	4. Despite of the positive financial and economic results for the five years under analysis (2010-2014), in 2011 the SJH was merged with the *Nossa Senhora Conceição Valongo* Hospital and a containment plan was introduced, given the financial and economic crisis. What was the impact of these measures on hospital activity? And what was the *HVITAL*'s role?	- Was it useful? In which way? - Had the *HVITAL* contributed for a better decision making?
- Planning and control	5. In the annual report of 2013 one can read that "the internal situation in Portugal and the international crisis, accompanied by the measures implemented by Executive followed by Troika's intervention, made 2013 one of the most difficult years in the history of the *São João*" (CHSJ, 2013). What has been the impact of these measures in the hospital's activity? And what has been the *HVITAL*'s role?	- Has the *HVITAL* been useful? In which way? - Has the *HVITAL* been contributed for a better decision making?
- Planning and control - Intelligence ISs	6. In 2014 the *HVITAL* made two years since its implementation. Both accounts and the objectives signed with the ACSS had positively exceeded the results of previous years. Do you consider that the *HVITAL* had impact on these results?	- If yes, in which dimensions (financial and economic, operational, clinical)? - If no, why not? - What other factors contributed to the improvements?
- Planning and control	7. In the years of 2013 and 2014 one can verify greater rigor in the presentation of the results of the quality and efficiency objectives. What has changed compared to previous years?	- These indicators began to be a greater source of concern? - Do you consider that this improvement was influenced by the implementation of the monitoring system for national hospitals' performance (benchmarking) in 2013 by ACSS?

Dimension(s)	Questions	Prompts/Probes
	8. In 2013 a monitoring system for national hospital's performance (benchmarking) was implemented by ACSS. Is it possible to monitor all indicators included in this system at the SJHC through the *HVITAL*?	- What are the main advantages to do this real-time monitoring? - Is it possible to take corrective actions whenever the results fall below what is expected?
- Intelligence ISs	9. In a brief description, what were the guidelines given by the SJHC's Board of Directors to design the *HVITAL's* project and how it was operationalised?	- How did you decide by Microsoft®*?* And by DevScope consultancy agency? - What has been the role of the DevScope*?*
- Intelligence ISs	10. On average, how many KPIs did you start to monitor management and clinical processes? How many KPIs do you have currently?	- Who proposed the KPIs? - Are you responsible for add KPIs whenever is needed?
- Intelligence ISs	11. The annual report of 2010 refers to a project called "*Medir para melhor gerir*" (meaning "Measuring to better manage*"*). This project still exist? If so, what is the main difference between this project and the *HVITAL*?	
- Planning and control - Clinical Care	12. What are the main effects of the *HVITAL* at the diagnosis and treatment levels?	- Is it useful? How? - Is it contribute for a better decision making and better outcomes to patients?
- Planning and control - Clinical Care	13. What are the main benefits of the *HVITAL* at the nursing care levels?	- Is it useful? How? - Is it contribute for a better decision making and better outcomes to patients?
- Planning and control - Clinical Care	14. According to the OECD (2015), the PHS has progressed at the clinical processes' levels. However, the average length of stay is still a source of concern. In the case of the SJHC, after the *HVITAL's* implementation, the	- If yes, how? - There is room for improvement? If so, in which way? What is the role of the *HVITAL* in the improvement process?

Dimension(s)	Questions	Prompts/Probes
	average length of stay decreases from 7,96 days in 2011 to 7,71 in 2014. Do you consider that the *HVITAL* had impact on this result?	- What other factors contributed to these improvements?
- Planning and control - Clinical Care	15. According to the OECD (2015), the PHS is still below to the OECD countries' average at the level of discharging patients with certain medical conditions. At the SJHC, the Haematology is one of the services which must contributed for a high average length of stay. However, considering the most prevalent diseases, the average length of stay is decreasing. Do you consider that the *HVITAL* had impact on this result?	- If yes, how? - There is room for improvement? If so, in which way? What is the role of the *HVITAL* in the improvement process? - What other factors contributed to these improvements?
- Planning and control - Clinical Care	16. According to the OECD (2015), in the last decades ambulatory surgery has been increasing exponentially. However, the PHS is still below to the OECD countries' average. At the SJHC, after the *HVITAL*'s implementation the percentage of ambulatory surgery increased from 49,06% (in 2010) to 77,1% (in 2014). Do you consider that the *HVITAL* had impact on this result?	- If yes, how? - There is room for improvement? If so, in which way? What is the role of the *HVITAL* in the improvement process? - What other factors contributed to the improvements?
- Quality and patient safety - Healthcare-associated infections	17. According to the OECD (2015), the PHS has been progressing at the clinical processes. However, patient safety (e.g. healthcare-associated infections) is a source of concern. Do you consider that the *HVITAL* has been contributed to the improvement of patient safety at the SJHC?	- If yes, how? - There is room for improvement? If so, in which way? What is the role of the *HVITAL* in the improvement process? - What other factors contributed to the improvements?
- Quality and patient safety	18. What is the role of the *HVITAL* regarding to monitoring falls?	- Is it useful? How?

Dimension(s)	Questions	Prompts/Probes
- Quality and patient safety	19. In 2014, the Quality and Patient Safety Department collaborated in the design, validation and integration of the *HVITAL* to classify inpatients' clinical deterioration risk. This seems to be a good practice to improve efficiency and quality. In a brief description, what has been done?	- What are the KPIs used? Can you mention some examples? - What are the main outcomes until now? And what is the role of the *HVITAL* in this project?
- Healthcare-associated infections	20. According to the annual report of 2014, it was a key year for the Unit for Prevention and Control of Infection and Antimicrobial Resistance (also known as *UPCIRA*) regarding to the development of tools to support epidemiological surveillance and assist the prescription of antimicrobials (CHSJ, 2014). In a brief description, what has been done?	- What are the KPIs used? Can you mention some examples? - What are the main outcomes until now? And what is the role of the *HVITAL* in this project?
- Planning and control - Intelligence ISs - Clinical Care - Quality and patient safety - Healthcare-associated infections	21. In 2014 the *HVITAL's* project made two years since its implementation. In terms of quality and efficiency objectives the results exceeded those of previous years. Do you consider that the *HVITAL* had impact on the results?	- If yes, how? - What other factors contributed to the improvements?
- Inventory management	22. Is there any IS to direct debit the medical supplies consumed?	- If yes, is the system integrated with the *HVITAL*? - What are the advantages of this integration?
- Inventory management	23. In 2011, the SJHC implemented a containment plan with effects on medicines and medical supplies' acquisition. Given the budget constraints, do you consider the *HVITAL* a valuable asset to stock management?	- If yes, how? - If no, why not?
- Planning and control - Inventory management	24. After the *HVITAL's* implementation, the number of days the SJHC usually takes to pay to suppliers has decreased achieving 75 days in 2014. Do you consider that the *HVITAL* had impact on this result?	- If yes, how? - What other factors contributed to this improvement?

Dimension(s)	Questions	Prompts/Probes
- Inventory management	25. After the *HVITAL's* implementation the inventory turnover has been increasing. Do you consider that the *HVITAL* had impact on this result?	- If yes, how? - What other factors contributed to this improvement?
- Internal audit	26. Concerning to the risk management, do you think that the *HVITAL* is valuable to identify high risk areas?	- If yes, how?
- Planning and control - Intelligence ISs - Clinical car - Quality and patient safety - Healthcare-associated infections - Inventory management Internal audit	27. From 2012 until now, has the *HVITAL* made some progress?	- If yes, may you mention some examples?
- Planning and control - Intelligence ISs - Clinical care - Quality and patient safety - Healthcare-associated infections - Inventory management - Internal audit	28. After three years of implementation, what is the balance of the *HVITAL*?	- There is room for improvement? - What do you need for the *HVITAL* can progress further? - What are the future potential outcomes?

Source(s): Self-elaboration

Appendix 2 – Production objectives of the SJHC (2010-2014)

	2010	2011	2012	2013	2014
Production line					
1. Outpatient					
1.1 Total of medical visits	n/a	n/a	n/a	667 916	684 991
1.1.1 First medical visits	n/a	n/a	n/a	173 849	180 611
1.1.2 Subsequent medical visits	26 677	n/a	n/a	494 067	504 380
2. Hospital stays – Discharged patients – Acute patients					
DRG – Medical	659	n/a	n/a	23 099	23 320
DRG – Surgical	2 008	n/a	n/a	19 847	13 927
DRG – Scheduled Surgical	n/a	n/a	n/a	13 826	5 356
DRG – Urgent Surgical	n/a	n/a	n/a	6 021	9 852
Prosthesis	n/a	n/a	n/a	333	n/a
Gastric banding	n/a	n/a	n/a	0	n/a
Cardiac defibrillator	n/a	n/a	n/a	77	n/a
Hip prosthesis	n/a	n/a	n/a	192	n/a
Intracranial neurostimulator	n/a	n/a	n/a	55	n/a
Medullary neurostimulator	n/a	n/a	n/a	8	n/a
Days of hospitalization – chronic or resident patients	n/a	n/a	n/a	5 287	9 852
Psychiatry – at the hospital	n/a	n/a	n/a	475	n/a
Chronically ventilated patients	n/a	n/a	n/a	730	n/a
Physical Medicine and Rehabilitation patients	n/a	n/a	n/a	4 082	n/a
3. Emergency					
Healthcare provided (without admission)	6 280	n/a	n/a	254 043	242 669
Total of patients in Accident and Emergency	n/a	n/a	n/a	215 599	225 368
Total of in Basic Accident and Emergency	n/a	n/a	n/a	38 444	17 031
Hospital day care	n/a	n/a	n/a	78 039	76 500

Haematology	252	n/a	n/a	50	2 624
Immuno-Haemotherapy	n/a	n/a	n/a	2 449	1 816
Psychiatry (Adult, Infants and Adolescents)	n/a	n/a	n/a	10 000	7 854
Other	12 453	n/a	n/a	65 540	64 992
Dialysis	n/a	n/a	n/a	n/a	n/a
Haemodialysis	n/a	n/a	n/a	n/a	n/a
Peritoneal Dialysis	n/a	n/a	n/a	n/a	n/a
Patient	34	n/a	n/a	n/a	n/a
4. Unid. Sócio Ocupacionais/Estruturas Reabilitativas (Instituição)	n/a	n/a	n/a	1268	2547
5. Home Health care	268	n/a	n/a	1669	2183
DRG – Outpatient clinic	n/a	n/a	n/a	33947	35743
DRG – Medical	n/a	n/a	n/a	16057	17636
DRG – Surgical	2193	n/a	n/a	17890	18380
Radiotherapy sessions	n/a	n/a	n/a	24556	22522
Simple treatment	n/a	n/a	n/a	22720	19194
Complex treatment	n/a	n/a	n/a	1178	3328
6. Health Programs					
Prenatal diagnosis – Number of Protocols I	n/a	n/a	n/a	992	1258
Prenatal diagnosis – Number of Protocols II	n/a	n/a	n/a	921	1102
HIV/AIDS – Total of patients	n/a	n/a	n/a	1910	1920
Termination of pregnancy up 10 weeks					
Termination of pregnancy up 10 weeks – ambulatory cases by medicines	61	n/a	n/a	568	498
Termination of pregnancy up 10 weeks – ambulatory cases by surgery	n/a	n/a	n/a	4	1
Multiple Sclerosis – Total of patients	n/a	n/a	n/a	353	375
Hepatitis C – Number of new patients in treatment	n/a	n/a	n/a	26	n/a
Oncology Pathology	n/a	n/a	n/a	253	728
Breast cancer – number of patients in treatment (first year)	n/a	n/a	n/a	153	n/a

Cervical cancer – number of patients in treatment (first year)	n/a	n/a	n/a	7	n/a
Colon and rectal cancer – number of patients in treatment (first year)	n/a	n/a	n/a	93	n/a
Lysosomal diseases – patients in treatment	n/a	n/a	n/a	n/a	32
Infertility diagnosis and treatment	n/a	n/a	n/a		
Number of fertility support consultations	n/a	n/a	n/a	316	366
Number of ovulation inductions	n/a	n/a	n/a	55	83
Number of intrauterine insemination	n/a	n/a	n/a	93	94
Number of in vitro fertilization	n/a	n/a	n/a	77	75
Number of intracytoplasmic sperm injection	n/a	n/a	n/a	224	220
Number of intracytoplasmic sperm injection collected by surgery	n/a	n/a	n/a	44	47
Medicines – free dispensing in outpatient clinic	n/a	n/a	n/a	5323776	n/a
Interns	n/a	n/a	n/a	2587047	n/a
Institutional incentives (5% of CP)	n/a	n/a	n/a	n/a	14.914.260€

Source(s): Hospital de São João, EPE (2010); Centro Hospitalar de São João, EPE (2011); Centro Hospitalar de São João, EPE (2012); Centro Hospitalar de São João, EPE (2013); Administração Central do Sistema de Saúde, IP (2013); Centro Hospitalar de São João, EPE (2014); OECD (2015) (n/a – not applicable or not available)

Appendix 3 – Quality's and efficiency objectives of the SJHC (2014)

Areas	Indicators	Weight
National objectives		**60%**
A. Access		**15%**
	A.1 Percentage of first medical outpatient visit in the total of medical visits	3%
	A.2 Percentage of patients referred for outpatient at the adequate time	3%
	A.3 Percentage of outpatients discharged in the total outpatients visits	3%
	A.4 Percentage of surgical patients treated in a timely manner	3%
	A.5 Inpatients referred to the Long-term Care Network in a timely manner	3%
B. Clinical performance		**25%**
	B.1 Average length of stay (days)	4%
	B.2 Percentage of readmissions within 30 days	4%
	B.3 Percentage of patients with a length of stay above the maximum threshold	4%
	B.4 Percentage of hip fractures with surgery performed within 48 hours of admission	4%
	B.5 Percentage of day case surgery in total elective surgeries (among surgical procedures that can be performed in day-case setting)	3%
	B.6 Percentage of generic medicines prescribed	3%
	B.7 Percentage of surgeries where the Surgical Safety Checklist has been used	3%
C. Economic and financial performance		**20%**
	C.1 Percentage of spending on overtime, supplements, and sub-contracting in the total of personnel expenses	5%
	C.2 Reporting a positive or null earnings before interest, taxes, depreciation, and amortization (EBITDA) (%)	5%
	C.3 Growth of debts overdue	5%
	C.4 Percentage of extra operating income to that it was signed in total operating income	5%
Regional objectives		**40%**

	D.1 Length of time for outpatient screening (days)	6%
	D.2 Starting of diabetic retinopathy treatment within 30 days	5,5%
	D.3 Referral rate for long-term care network	6%
	D.4 Outpatient/emergency ratio	5,5%
	D.5 "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded	5,5%
	D.6 Palliative care	5,5%
	D.7 Healthcare-associated infections control	6%

Source(s): Administração Central do Sistema de Saúde, IP (2014); Centro Hospitalar de São João, EPE (2014)

Appendix 4 – Quality's and efficiency objectives of the SJHC (model)

	2010	2011	2012	2013	2014
National objectives (60%)					
A. Access					
A.1. Percentage of first medical outpatient visit in the total of medical visits					
A.2. Percentage of patients referred for outpatient at the adequate time					
A.3. Percentage of outpatients discharged in the total outpatients visits					
A.4. Percentage of surgical patients treated in a timely manner					
A.5. Inpatients referred to the Long-term Care Network in a timely manner					
B. Clinical performance					
B.1. Average length of stay (days)					
B.2. Percentage of readmissions within 30 days					
B.3. Percentage of patients with a length of stay above the maximum threshold					
B.4. Percentage of hip fractures with surgery performed within 48 hours of admission					
B.5. Percentage of day case surgery in total elective surgeries (among surgical procedures that can be performed in day-case setting)					
B.6. Percentage of generic medicines prescribed					
B.7. Percentage of surgeries where the Surgical Safety Checklist has been used					
C. Economic and financial performance					
C.1. Percentage of spending on overtime, supplements, and sub-contracting in the total personnel expenses					
C.2. Reporting a positive or null earnings before interest, taxes, depreciation, and amortization (EBITDA) (%)					

C.3. Growth of debts overdue					
C.4. Percentage of extra operating income to that it was signed in total operating income					
Regional objectives (40%)					
D.1. Length of time for outpatient screening (days)					
D.2. Starting of diabetic retinopathy treatment within 30 days					
D.3. Referral rate for long-term care network					
D.4. Outpatient/emergency ratio					
D.5. "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded					
D.6. Palliative care					
D.7. Healthcare-associated infections control					

Source: Administração Central do Sistema de Saúde, IP (2014)

Appendix 5 – Quality's and efficiency objectives of the SJHC (2013)

Areas	Indicators	Weight
National objectives		**60%**
A. Access		**15%**
	A.1 Percentage of first medical outpatient visit in the total of medical visits	3%
	A.2 Percentage of patients referred for outpatient at the adequate time	3%
	A.3 Percentage of outpatients discharged in the total outpatients visits	3%
	A.4 Percentage of surgical patients treated in a timely manner	3%
	A.5 Inpatients referred to the Long-term Care Network in a timely manner	3%
B. Clinical performance		**25%**
	B.1 Average length of stay (days)	4%
	B.2 Percentage of readmissions within 30 days	4%
	B.3 Percentage of patients with a length of stay above the maximum threshold	4%
	B.4 Percentage of hip fractures with surgery performed within 48 hours of admission	4%
	B.5 Percentage of day case surgery in total elective surgeries (among surgical procedures that can be performed in day-case setting)	3%
	B.6 Percentage of generic medicines prescribed	3%
	B.7 Percentage of surgeries where the Surgical Safety Checklist has been used	3%
C. Economic and financial performance		**20%**
	C.1 Percentage of spending on overtime, supplements, and sub-contracting in the total of personnel expenses	5%
	C.2 Reporting a positive or null earnings before interest, taxes, depreciation, and amortization (EBITDA) (%)	5%
	C.3 Growth of debts overdue	5%
	C.4 Percentage of extra operating income to that it was signed in total operating income	5%
Regional objectives		**40%**

	D.1 Length of time for outpatient screening (days)	n/a
	D.2 Starting of diabetic retinopathy treatment within 30 days	n/a
	D.3 Referral rate for long-term care network	n/a
	D.4 Outpatient/emergency ratio	n/a
	D.5 "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded	n/a
	D.6 Implementation of palliative care teams	n/a
	D.7 Healthcare-associated infections control	n/a
	D.8 Reduction of the number of anticoagulation consultations over the previous year	n/a

Source(s): Administração Central do Sistema de Saúde, IP (2013); Centro Hospitalar de São João, EPE (2013)

Appendix 6 – Quality's and efficiency objectives of the SJHC (2012)

Areas	Indicators	Weight
National objectives		**50%**
A. Access		**15%**
	A.1 Percentage of first medical outpatient visit in the total of medical visits	3%
	A.2 Percentage of patients referred for outpatient at the adequate time	3%
	A.3 Percentage of outpatients discharged in the total outpatients visits	3%
	A.4 Percentage of surgical patients treated in a timely manner	3%
	A.5 Inpatients referred to the Long-term Care Network in a timely manner	3%
B. Clinical performance		**20%**
	B.1 Average length of stay (days)	5%
	B.2 Percentage of readmissions within 30 days	3%
	B.3 Percentage of patients with a length of stay above the maximum threshold	3%
	B.4 Percentage of births by caesarean section	3%
	B.5 Percentage of day case surgery in total elective surgeries	3%
	B.6 Percentage of generic medicines prescribed	3%
C. Economic and financial performance		**15%**
	C.1 Percentage of spending on overtime, supplements, and sub-contracting in the total of personnel expenses	3%
	C.2 Reporting a positive or null earnings before interest, taxes, depreciation, and amortization (EBITDA) (%)	3%
	C.3 Growth of debts overdue	3%
	C.4 Percentage of extra operating income to that it was signed in total operating income	3%
	C.5 Percentage of adjusted costs with staff in operating income	3%
Regional objectives		**50%**
	D.1 Maximum waiting time for first consultation (days)	n/a

	D.2 Maximum waiting time for surgery (months)	n/a
	D.3 Referral rate for long-term care network	n/a
	D.4 Outpatient/emergency ratio	n/a
	D.5 "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded	n/a
	D.6 Reduction of the number of anticoagulation consultations over the previous year	n/a

Source(s): Administração Central do Sistema de Saúde, IP (2012); Centro Hospitalar de São João, EPE (2012) (n/a – not applicable or not available)

Appendix 7 – Quality's and efficiency objectives of the SJHC (2011)

Areas	Indicators	Weight
National objectives		**30%**
A. Quality and service		n/a
	A.1 Percentage of rehospitalisation in the first five days	10%
	A.2 Percentage of births by caesarean section	10%
B. Access		n/a
	B.1 Percentage of first medical outpatient visit in the total of medical visits	10%
	B.2 Median between the admission date and the referral date to the Long-term Care Network (days)	10%
	B.3 Outpatient/emergency Ratio	10%
C. Clinical performance		n/a
	C.1 Percentage of day case surgery in total elective surgeries	10%
	C.2 Average length of stay (days)	10%
	C.3 Percentage of generic medicines prescribed	10%
D. Economic and financial performance		n/a
	D.1 Percentage of costs with staff adjusted in operating income	10%
	D.2 Operating income	10%
Regional objectives		**20%**
	E.1 Variation of percentage of sub-contracting	35%
	E.2 Variation of percentage of consumption	30%
	E.3 Variation of percentage of staff costs	35%
Regional objectives (other)		**50%**
	F.1 Maximum waiting time for first consultation (days)	n/a
	F.2 Maximum waiting time for surgery (months)	n/a
	F.3 Emergency stay – percentage of patients under four hours	n/a
	F.4 "*Via Verde do AVC*" – percentage of cases with primary diagnosis of acute ischaemic stroke with thrombolytic treatment recorded	n/a

Source(s): Administração Central do Sistema de Saúde, IP (2011); Centro Hospitalar de São João, EPE (2011) (n/a – not applicable or not available)

Appendix 8 – Quality's and efficiency objectives of the SJHC (2010)

Areas	Indicators	Weight
A. National objectives		**50%**
	Percentage of first medical outpatient visit in the total of medical visits	13%
	Median between the admission date and the referral date to the Long-term Care Network (days)	10%
	Percentage of rehospitalisation in the first five days	10%
	Average length of stay (days)	12%
	Percentage of day case surgery in total elective surgeries	12%
	Percentage of episodes of inpatient surgical complications (including septicaemia)	10%
	Percentage of pressure ulcers as additional diagnosis	10%
	Percentage of vaginal births performed with epidural analgesia	10%
	Percentage of births by caesarean section	13%
	Percentage of costs with staff adjusted in operating income	20%
	Days payables outstanding	20%
	Variation of percentage of operating income	20%
	Solvency	20%
	Shareholder equity	20%
Regional objectives		**50%**
	Variation of percentage of sub-contracting	35%
	Variation of percentage of consumption	30%
	Variation of percentage of staff costs	35%
Regional objectives (other)		**50%**
	Maximum waiting time for first consultation (days)	<365days
	Maximum waiting time for surgery (months)	<12 months
	Percentage of caesarean sections	28%

Source(s): Administração Central do Sistema de Saúde, IP (2010); Hospital de São João, EPE (2010)

Appendix 9 – Thematic framework

1. **Previous organisational context (to *HVITAL*'s implementation)**
    - 1.1 Background
    - 1.2 Inefficiencies
2. ***HVITAL's* implementation process**
    - 2.1 Strategies
    - 2.2 Indicators
3. ***HVITAL's* impact on management performance**
    - 3.1 Planning and control
    - 3.2 Internal audit
    - 3.3 Inventory management
    - 3.4 Other
    - 3.5 Balance
4. ***HVITAL's* impact on clinical performance**
    - 4.1 Clinical care (medical and nursing)
    - 4.2 Quality and patient safety
    - 4.3 Healthcare-associated infections
    - 4.4 Other
    - 4.5 Balance
5. **Other factors related to the improvement of the SJHC's performance**
    - 5.1 Individual factors
    - 5.2 Organisational factors
6. ***HVITAL* future**
    - 6.1 Expected improvements
    - 6.2 Potential Outcomes

Source(s): Self-elaboration

Appendix 10 - Thematic matrix

7. *HVITAL's* future

Case name	7.1 Expected improvements	7.2 Potential outcomes
Manager	"The *HVITAL* has changed a lot since 2012, and it will continue to change for the future. There are always things. When we open a door to people, they always want more because this door will give them other perspective (…). In my area, we want the integration of the Balanced Scorecard application with the *HVITAL* platform (…). The intention is to get information about the Balanced Scorecard indicators automatically through the *HVITAL*."	n/a
Manager	"The *HVITAL* is not completed, it is always under construction because there are always new things to integrate. There are always new indicators or variables that we want to include. Basically, it is an unfinished work."	n/a
Manager	"I need a bigger team to start working in an area that is very important that is Artificial Intelligence."	"My ambition is that this solution can help increasingly stratifying the risk of each patient accurately, from the moment that the patient comes to the hospital to every single day of hospitalisation, measuring accurately what is the likelihood of

Case name	7.1 Expected improvements	7.2 Potential outcomes
		the patient get a multidrug-resistant infection, or a thromboembolism, or respond better to the antibiotic A comparing with the antibiotic B, among other things, and give this information to clinicians in real-time. On the day that clinicians have this information in a second, we will be able to compete with the best American clinics."
Manager	"There are plenty perspectives of improvement."	"On Artificial Intelligent issues. There are no limits, even at the management level. At clinical level, create an Artificial Intelligent model will be phenomenal, The future is unlimited on this type of things."
Healthcare Professional	"Yes, there are always room for improvement (…). I would like to have more clinical control. The management control we do have, and we will not progress much more. All the parameters required by the ACSS in terms of quality are also already measured by the *HVITAL*. The *HVITAL* is evolving more in the clinical area, and it makes sense because its role on this area should grow." "For example, the monitoring of the response time of collaborative requests to Cardiology, Imunohaemotherapy,	"Creating projects, which becomes easier with the information provided by the *HVITAL*"

Case name	7.1 Expected improvements	7.2 Potential outcomes
	Medical imaging, among others, is something that also could be very useful, since it interferes in the waiting times for surgery."	
Manager	"I think there is always room for improvement, I cannot think that it is a finished product and that cannot evolve. The *HVITAL* has evolved and will continuing to do it, because the hospital has demanding needs to be satisfied. I think that we will have to use this tool and the information provided by it to produce more indicators in order to improve our activity."	n/a
Healthcare Professional	"There is plenty room for improvement. Within the patient safety area for example, allergies and adverse reactions is an area that concern me because there is a national and international indication that obligate the documentation of them, and we are documenting this in an area of an IS that does not be recommended. This is something that we have to work, and now with the Quality and Patient Safety department we must integrate this type of things with the *HVITAL* (…) If the *HVITAL* did not exist it would be much difficult, but with this	"The *HVITAL* gives us the opportunity of a multitude of things, people just need to think about it. The *HVITAL* has a great potential." "There are many areas of opportunity. In short time we will have important data related, for example, with the relationship between indicators such as the effectiveness of antibiotics for a given infection and the patient's characteristics and probably we will know that we just need give that antibiotic for five days instead of seven days, which contributes to reduce costs and hospital stays."

Case name	7.1 Expected improvements	7.2 Potential outcomes
	tool I believe that will be an opportunity to do this better and faster."	
Healthcare Professional	"We gave the first steps on the production indicators area, but we have much more to do. The model is very good, but we need to create more, and especially in Nursing area I would like to have more support to create more indicators. I understand the decisions and the priority areas where the indicators of the *HVITAL* has being developed, but I want more in Nursing area (…). If we cannot prove our performance with basis on numbers, we cannot prove our value".	"The *HVITAL* has a lot of potential to create more production indicators in Nursing area."
Healthcare Professional	"I think there is a lot of work to do with the services. On the one hand, it is necessary train people and make them aware of that is the systematic approach to quality management and what it can bring. This is an issue that is not specific to the *HVITAL*, anyway, we still have many professional not sensitive to these issues and we need to work hard with them about the safety culture. When people watch to public presentations about these intelligence tools, they think that it is spectacular, but if these tools don't have impact on what we daily do or if people don't	n/a

Case name	7.1 Expected improvements	7.2 Potential outcomes
	know the real impact of the *HVITAL* on what they do it will not have any impact on the quality and patient safety improvements. I think that there is still much to do about this, and I take the responsibility to do, to promote or to facilitate this culture changing, by delivering information gathered from the *HVITAL* explaining its usefulness, and promoting training as needed."	
Healthcare Professional	"In the long run we are trying to model a population of motivated clinicians to gather real-time information (....) To accomplish that, we are training the youngest clinicians, since it is easier to the older ones change their attitude by the influence of other. This investment will bring some "fruits" over time. And, at some times, it is already noticeable. Just yesterday we had a request for training (…)."	"(…) and what we think that can be a future step is the determination of risk factors that could eventually contribute to predict where are the risk patients and implement preventive measures before the beginning of multidrug-resistant microorganisms. This can only be achieved with t tool such as this one. "
Manager	n/a	n/a
Manager	"One thing that we already requested and we think it is important is the integration of the SISQUAL database, i.e. the biometric registration, with the BI platform. For example, if I want to make a data matching between the biometric	n/a

Case name	7.1 Expected improvements	7.2 Potential outcomes
	registration and the payroll the only way I can do it is use the payroll data that I have in the *HVITAL*, but the biometric registration I have to do a manual reading because it is not integrated with the *HVITAL*. In terms of auditing samples, this process reduces greatly my scope field because If I would have all data in the *HVITAL* instead of having to use manual timesheets I almost could do it for whole population. In this case, I just can check a very limited sample, having no chance to use a representative sample of the hospital. (…)When integrated with the *HVITAL* will be much easier to make this intersection." "In terms of my work, the issues are about the integration of both biometric registration and user charges with the *HVITAL*."	

Source(s):Self-elaboration (n/a – not applicable or not available)

Appendix 11 – Elements, dimensions and categories

Theme	Subtheme	Elements	Dimensions	Categories
1. Previous organisational context (to *HVITAL's* implementation)	1.1 Background	- It was the first that I have contact - It was like water to wine - We have data in a distance of a click - it is a significantly difference compared to other sites	- Comparison between the pre and post-implementation with other institutions	**Reasons of implementation**
		- I had to prepare my «*Tableau de Bord*» - We had to extract data directly from ISs - There was nothing similar - We had an intermediate stage, with a management reporting platform - The reporting platform was the foundation to build the BI project - We could only analyse the variables pre-selected - Something that could not be done quickly - There was no room or time to explore more	- Comparison between the pre and post-implementation	

Theme	Subtheme	Elements	Dimensions	Categories
	1.2 Inefficiencies	- We needed more information either in quantity or in quality, in a timely manner - Information dispersed, poorly organised and non-integrated - Impossible to perform an accurate and reliable analysis - The hospital needed good information to make good decisions - We thought the information was not right, but we had no mechanisms or means to correct it - Not possible to correct deviations in time - We could not manage income or costs properly - Standardised maps were very limited - Some correlations had never been made - Very difficult to get conclusions about data - Made mistakes, getting different numbers of reality - Never know if the information was right or not	- Poor information quality	
		- I had to collect information manually - The reaction time was too long	- Ineffective access to information	

Theme	Subtheme	Elements	Dimensions	Categories
		- Not having access to accurate and time information on indicators - I had to call to someone - I needed to ask for someone - The pharmaceutical had to verbally communicate the antibiotics prescribed - Sometimes information was lost - Write the results on paper - Lack of interoperability among ISs - I had to call to the operating room, which was very time-consuming - User were very restricted - The report could take two or three weeks to be ready - Some analyses were not possible to do - some correlations had never been made		
3. *HVITAL*'s implementation process	3.1 Strategies	- The Board of Directors decided - This specialisation has a great component of BI systems - I had a clear vision of what I wanted to implement	- Decision power - Previous knowledge	**Operationalisation**

Theme	Subtheme	Elements	Dimensions	Categories
		- With a small budget - Choose the best team - To solve the most important issues on human resources, financial, supply and logistics, and production areas.	- Conditions	
		- The DevScope® provided consultancy - They brought me experts in each components	- Professionals recruitment	
		- I chose the Microsoft - Licensing values, far below from other market suppliers -A range of online content, training videos free of charges	- Software choice	
		- At the beginning capabilities for management control - Suddenly, we started to realise that we could use the *HVITAL* to help saving patients' lives	- Areas to monitor performance levels	
	3.2 Indicators	- We started with around 200-250 KPIs - Now we have 650 KPIs	- Number of indicators	

Theme	Subtheme	Elements	Dimensions	Categories
		- Initially, these indicators were proposed by the planning and control department - The KPIs are inserted by me or by DevScope - We can access them in a daily basis - We monitor the indicators of the CP every single month	- Development of KPIs - Frequency of monitoring	
4. *HVITAL's* impact on management performance	4.1 Planning and control	- Influencing positively many processes and procedures - Optimise resources, rules and procedures - We have information in a timely manner, reliable and user-friendly -Excellent budget and CPs execution rates - I can easily and quickly access a great amount of information - Today, there is no limit - Adopt immediately correct measures - We are financially stable because we have a BCI that allow us to understand the effect, the consequence and the impact of the acts - The answer is positive in the quality and efficiency results	- Advantages	**Management outcomes**

Theme	Subtheme	Elements	Dimensions	Categories
		- Possibility of monitor indicators in more detail and regularly - Impact in all levels: financial, efficiency and quality - To know what we are spending, saving and investing - Controlling the operating rooms, number of beds, medicines prescription and stocks - I can do a map every single day - To adapt corrective strategies	- Examples of utilisation	
	4.2 Internal audit	- Is certainly an asset - More comprehensive analyses - The possibility of extending samples - I do not have to recur routinely to intermediaries - Not having to spend a lot of time asking for help - Evaluate a number of variables such as the type of contract, and see if we have many direct adjustments, public procurements, which amounts are involved	- Advantages - Examples of utilisation	

Theme	Subtheme	Elements	Dimensions	Categories
		- I can easily check the evolution of purchases, stocks, consumption		
	4.3 Inventory management	- We have information in real-time - Allow to do things faster - The stock management become more efficient - The request and acquisition of goods passed from one day to half a day - Rupture analyses - Defining quickly the priorities of my day - Defining which suppliers do I have to contact - What materials are risk of running out in the next day	- Advantages - Examples of utilisation	
	4.4 Other	- Integration of two applications with the *HVITAL*, a Balanced Scorecard and a costing system - Instead of use two different "machines", and two separate *SONHO's* programs. - The *HVITAL* helped to gather information from both hospitals	- Projects - *HVITAL*'s role in the structural changes	

Theme	Subtheme	Elements	Dimensions	Categories
		- The results by the hospital are influenced by the *HVITAL*, especially in this period of time influenced by strong financial budget restrictions. - The hospital does not have overdebt and has a positive EBITDA		
	4.5 Balance	- Globally the balance is very positive - Ability to improve our performance levels, to make investments, reduce the debt to suppliers - The balance is excellent - This ability to make decisions with basis on reliable information is critical to improve quality of care	- Point of situation	
5. *HVITAL's* impact on clinical performance	5.1 Clinical care (medical and nursing)	- This can save lives - In the case of deviations we can implement actions to correct it - Give us an overview of what is happening with a patient - I can follow everything in the distance of a click -To check patients' progress and trends - Be able to prioritise the care according to patients' risk	- Advantages - Examples of utilisation	**Clinical outcomes**

Theme	Subtheme	Elements	Dimensions	Categories
		- To understand the linkage between practices and outcomes - Perform a number of analysis, combining different clinical indicators - *HVITAL* is having impact in operational terms - Percentage of malnourished inpatients		
	5.2 Quality and patient safety	- Finding a "partner" - Best conditions to get access to information, with a user-friendly interface - Helping us to monitoring all steps, the impact is huge - Understand the magnitude and the causes of admissions less than 24 hours	- Advantages - Examples of utilisation	
	5.3 Healthcare-associated infections	- Is adequately monitored since two years after the *HVITAL*'s implementation - Contributes to monitor monthly indicators - Overview of all patients, in real-time - Saving days of hospitalisation	-Advantages	

Theme	Subtheme	Elements	Dimensions	Categories
		- The antimicrobial assistance program is completely dependent on information provided by the *HVITAL* - The system also alert us whenever a patient has a multidrug-resistant infection -History of inpatient's antibiotic consumption by service	- Examples of utilisation	
	5.4 Other	- Develop scientific researches - Create the subspecialty of Paediatric Orthopaedics - European project under the Nutrition area - Working group - Project anchored in the *HVITAL*, measuring physiological state of patients	- Projects	
	5.5. Balance	- The balance is very positive - Helped us to improve some things - Healthcare professionals changing their decisions with basis on information	- Point of situation	
6. Other factors related to the	6.1 Individual factors	- Results obtained by the Professionals whom work in the hospital - People that do not accommodate	- Professional pride	**Organisational culture influences**

Theme	Subtheme	Elements	Dimensions	Categories
improvement of the SJHC's performance		- People that like to be challenged, and responded positively to the challenges - People's work. - Culture of "loving the shirt"		
	6.2 Organisational factors	- Strong leadership - Philosophy of management - Vision of the institution - Love by the *São João's* brand - Most notorious health brand among the Portuguese Hospitals - Support of the Board of Directors	- Hospital's brand image	
7. *HVITAL*'s future	7.1 Expected improvements	- Integration of Balanced Scorecard indicators with the *HVITAL* - Integration of biometric registration and user charges with the *HVITAL* - Better documentation of allergies and adverse reactions - Creation of other indicators or variables	- More integration - More indicators	**Modifications**

Theme	Subtheme	Elements	Dimensions	Categories
		- Creation of more production indicators, especially in Nursing area - Easy and quick access to all professionals - Training people and make them aware of the impact of the *HVITAL* on quality and patient safety - Motivating the oldest physicians and nurses through the newest ones - Make people aware of the clinical research potential	- Professionals inclusion - Training - Changing of attitude - Spread the word	
	7.2 Potential outcomes	- Artificial intelligent issues - Prediction ability - Ability to predict the patients at risk of getting a multidrug-resistant infections - Ability to predict the antibiotics effectiveness	- Data mining - Artificial intelligent	**Development of new analytical tools**

Source(s): Self-elaboration

Appendix 12 – Case study protocol

Overview of the case study project

- ✓ **Selection of the case and the criteria used:**
  - Exploratory case study.
  - Unit of analysis: SJHC.
  - Holistic, single-case design (revelatory case).
- ✓ **Objective of the case:**
  - Evaluate the impact of a BCI project, called *HVITAL*, implemented in the SJHC in 2012, for the period 2010 to 2014.
- ✓ **Significance of the phenomenon of interest:**
  - Tradition of inadequate management in healthcare organisations.
  - Growing demand of good health information.
  - Role of ISs providing timely performance measurements to support managerial decision-making process.
  - Lack of interoperability between the ISs in the healthcare organisations.
  - Poor information as one of the most difficulties to healthcare decision makers manage change in the PHS.
  - In the last decades, BI systems have been implemented with positive outcomes in several industries.
  - Recently, BI systems have started to be implemented in healthcare organisations.
  - The BI systems monitoring organisation activity, filtering the data gathered from databases and transforming it into useful information, processing it for strategic significance and efficiently communicating actionable intelligence to decision makers
  - Implementation of a BI system in a Portuguese hospital, who has been distinguished national and internationally for investing in the development of this innovation. Further, the SJHC was considered the best public hospital in Portugal for 2013 and 2014 (two consecutive years after the year of the *HVITAL's* implementation).
- ✓ **Relevant readings about the topic being investigated**
  - Planning and control in organisations, and particularly in healthcare.

- ISs and its role on performance measurement.
- Intelligence ISs.
- Published articles in databases about BI systems in healthcare organisations.

Case study questions

✓ **Questions being addressed for the case selected:**

- Why does the SJHC have shown positive economic and financial results in the recent years? Was this more evident after the *HVITAL's* implementation? What is the role of the *HVITAL* on the management control area?
- Why does the SJHC have shown improvements on quality and efficiency results in the recent years? Was this more evident after the *HVITAL's* implementation? What is the role of the *HVITAL* on the clinical area?
- Has the *HVITAL* any impact on management and/or clinical processes?
- What were the main reasons to implement a BI system in the SJHC? To reduce costs? To improve efficiency? To improve quality of care?
- How did the implementation process started? Who were the key players in the implementation process?
- What is the daily impact of the *HVITAL* in the hospital? What are the main effects of this project in the daily work of the professionals? What are the main differences after the *HVITAL's* implementation, at the management and clinical levels?
- What are the main advantages of implementing a BI system in a healthcare organisation, and particularly in a public Portuguese hospital? There are disadvantages?
- What can we learn from this real case?

✓ **Final research questions stated:**

- How did the *HVITAL's* project affect managerial performance?
- How did the *HVITAL's* project affect clinical performance?
- Why was the *HVITAL's* project implemented?
- How was the *HVITAL's* project implemented?

Data collection procedures

✓ **Gaining access to organisation and key interviewees:**

- Formal letter to Administration's Board;
- Email-s with the *HVITAL*'s project manager.

✓ **Data collection plan:**

- Definition of a data collection plan (i.e. schedule of activities);
- Decision of collection of multiple sources of evidence (documentary data and semi-structured interviews).
- Definition of storing data in a database, which were divided by the type of data (i.e. primary data and secondary data);
- Identification of the participants, by functional areas (i.e. Managers, Healthcare professionals and the *HVITAL*'s project manager);
- Preparation of the interview guide prior to go on site;
- Identification of the resources needed (i.e. recorded audio devices, personal computer).

Case study report

✓ Identification of the audience:

- Healthcare Managers;
- Healthcare professionals;
- SJHC's professionals;
- Scientific community.

✓ Determination of the structure of the case study report:

- Reference authors in the areas of planning and management control, ISs and BI systems;
- Outcomes from the practice to date (results of published articles);
- Case study presentation, including a brief overview of the PHS, the SJHC and the *HVITAL's* project;
- Methodology approach followed;
- Main findings;
- Discussion and conclusions.
- Appendixes and annexes.

Source(s): Yin (2009)

Annex A – Letter of collaboration

UAlg FE
UNIVERSIDADE DO ALGARVE
FACULDADE DE ECONOMIA

Faro, 21 de Outubro de 2014

A/C Exmo. Sr.
Dr. António Luís Trindade Sousa e Lobo Ferreira
Presidente do Conselho de Administração
Centro Hospitalar de São João, E.P.E.,

Assunto: Pedido de colaboração ao Conselho de Administração do Centro Hospitalar de São João, E.P.E., para a realização de uma dissertação de mestrado

Sara Filipa Salvador da Luz, atualmente a exercer funções de Enfermagem no Centro Hospitalar do Algarve, E.P.E. e a frequentar o Curso de Mestrado de Gestão de Unidades de Saúde na Faculdade de Economia da Universidade do Algarve vem por este meio solicitar a V/melhor colaboração para a realização de um *case study* sobre o Centro Hospitalar de São João, E.P.E., o qual pretende aferir sobre o impacto da implementação do V/projecto de *Business Intelligence HVITAL*.

A escolha deste tema é particularmente relevante no momento que atravessamos. De facto, são vários os estudos que sugerem uma melhoria da performance do nosso país em vários dos principais indicadores de Saúde monitorizados pelas agências internacionais. Infelizmente, a necessidade de conter o nível de despesa pública nos últimos anos tem afetado profundamente a capacidade para financiar este sector através do Orçamento do Estado, algo que se traduz em perdas claras para os utentes.

Desta forma, todas as medidas que permitam controlar custos e melhorar os níveis de eficiência e eficácia da operação hospitalar País assumem uma extrema importância. Neste contexto, o Centro Hospitalar de São João, E.P.E é claramente um exemplo a seguir, mormente no que toca à utilização de novas tecnologias para apoio à gestão. De facto, é de domínio público que o Centro Hospitalar que V/Ex.a dirige implementou o projeto-piloto *Business Intelligence HVITAL*, de forma a otimizar a recolha e tratamento da informação produzida internamente com vista à melhoria do processo de decisão.

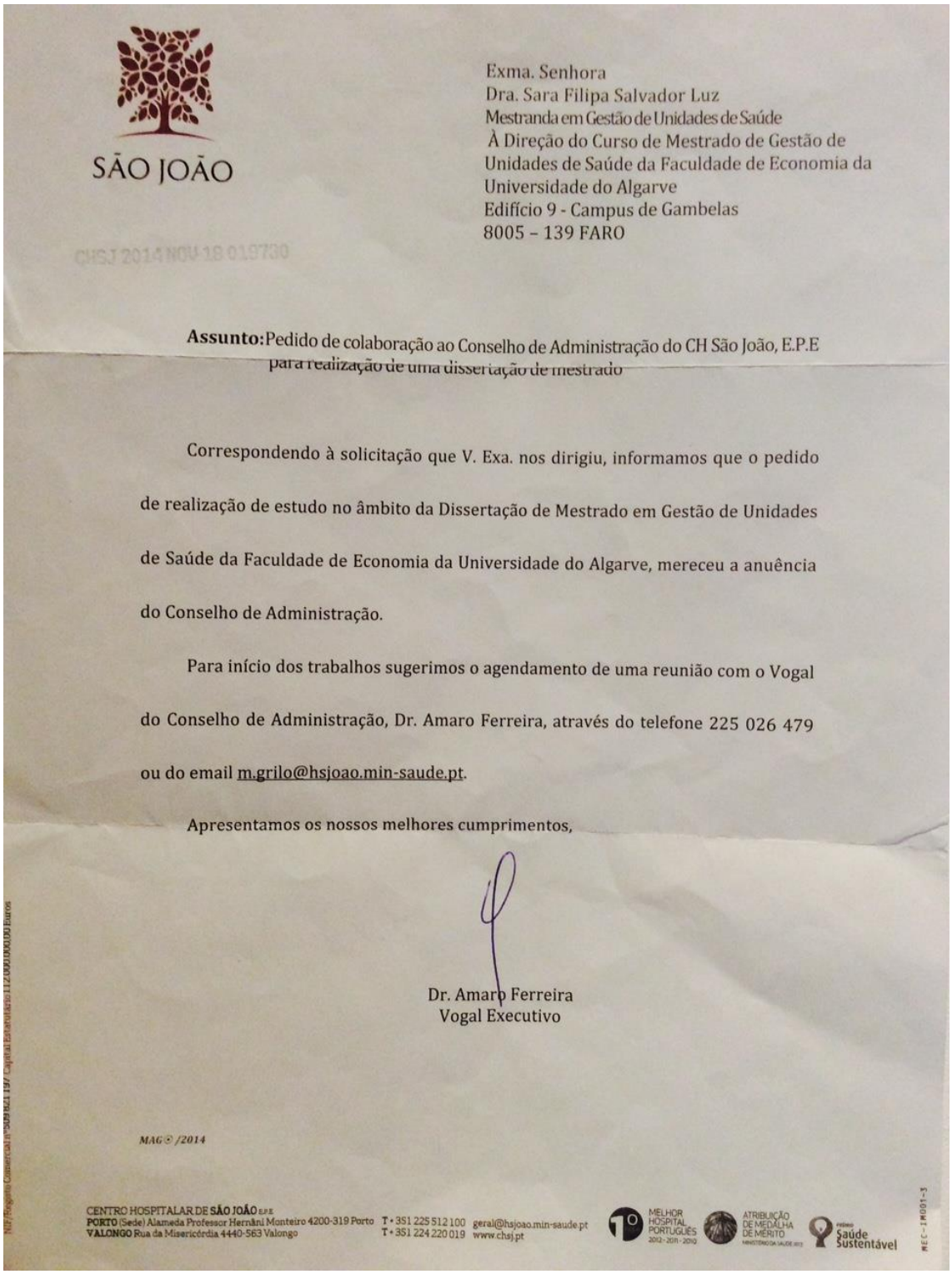
Esta é claramente uma *best practice* de gestão na área hospitalar, sendo por isso fundamental difundir a mesma pelos restantes Centros Hospitalares a operar em solo nacional. Tal trata, certamente, benefícios claros para todos e cada um deles e para os utentes do SNS em geral. Paralelamente é minha expectativa que o Centro Hospitalar de São João possa também beneficiar do estudo que ora me proponho realizar. De facto, a divulgação do mesmo no meio académico servirá para aumentar a visibilidade e notoriedade internacional do Centro Hospitalar que V/Ex.a dirige. Por outro lado, os resultados do estudo poderão enfatizar dimensões do projeto que ainda não estão totalmente claras, algo que poderia potenciar ainda mais o interesse desta ferramenta de gestão.

Face ao exposto, gostaria de solicitar que V/Ex.a se digne a autorizar a realização deste estudo e que permita o acesso a alguns recursos que são necessários à concretização do mesmo. Cabem nesta categoria alguma informação económica e financeira produzida pelo Centro Hospital e a possibilidade de entrevistar algumas das pessoas que estão diretamente envolvidas no projeto.

Sem mais assunto de momento subscrevo-me com a mais elevada consideração, ficando à disposição para qualquer esclarecimento que entenda necessário.

Sara Luz
Mestranda em Gestão de Unidades de Saúde

Annex B – Answer of collaboration's letter



SÃO JOÃO

Exma. Senhora
Dra. Sara Filipa Salvador Luz
Mestranda em Gestão de Unidades de Saúde
À Direção do Curso de Mestrado de Gestão de Unidades de Saúde da Faculdade de Economia da Universidade do Algarve
Edifício 9 - Campus de Gambelas
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CHSJ 2014 NOV 18 019730

Assunto: Pedido de colaboração ao Conselho de Administração do CH São João, E.P.E para realização de uma dissertação de mestrado

Correspondendo à solicitação que V. Exa. nos dirigiu, informamos que o pedido de realização de estudo no âmbito da Dissertação de Mestrado em Gestão de Unidades de Saúde da Faculdade de Economia da Universidade do Algarve, mereceu a anuência do Conselho de Administração.

Para início dos trabalhos sugerimos o agendamento de uma reunião com o Vogal do Conselho de Administração, Dr. Amaro Ferreira, através do telefone 225 026 479 ou do email m.grilo@hsjoao.min-saude.pt.

Apresentamos os nossos melhores cumprimentos,

Dr. Amaro Ferreira
Vogal Executivo

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Annex C – Interviewee's informed consent form

"The impact of Business and Clinical Intelligence project *HVITAL*: a case study in the S*ão João* Hospital Centre, *EPE"*

I am inviting the Mr. / Mrs. / Ms. to participate in a research study entitled by "The impact of Business and Clinical Intelligence project *HVITAL*: a case study in the *São João* Hospital Centre, *EPE*. This research study is being conducting as part of my Master's Degree requirements in Healthcare Management at the Faculty of Economics of the University of the Algarve, under the supervision of the Professor Dr Luís Coelho (Assistant Professor, Faculty of Economics, University of the Algarve) and Professor Dr Adão Flores (Assistant Professor, Faculty of Economics, University of the Algarve).

I, _____, with the title job of _____ in the *São João* Hospital Centre, *EPE*, state my agreement to participate freely and knowledgeable in the study with the title above mentioned.

The participant is knowledgeable that:

I) The objective of this study is to evaluate the impact of the *HVITAL's* project in the *São João* Hospital Centre, EPE;

II) The primary data will be collected from a sample of professionals working in the *São João* Hospital Centre, EPE, through the application of semi-structured interviews;

III) The semi-structured interviews will be recorded by two audio devices and the material gathered will be part of the study;

IV) Is volunteer and can interrupt the collaboration in the study at any time, without any explanation or prejudice about the decision.

V) The present study has strictly academic purposes, aiming to contribute to the development of the research in the area of Healthcare Management;

VI) Will not receive any remuneration or any compensation for the collaboration;

VII) Is agreeing that the results of this study can be published in scientific journals, provided that personal information remains confidential;

VII)) The study's presentation and discussion will be public and may also be subject to participation in national and international events;

IX) Can be informed about the results of the study by contacting the researcher, through telephone or e-mail.

( ) I want to know the results of this study.

( ) I do not want to know the results of this study.

I declare that all necessary information to participate in this study has been provided, as well as further clarification requested.

Participant:

_____ _____

(Signature) (Date)

Researcher:

_____ _____

(Signature) (Date)